AFRL-RH-WP-TR-2009-0060

Anticipating Job Aiding and Training Requirements

Patrick J. Vincent
Northrop Grumman Information Technologies
2555 University Boulevard
Fairborn OH 45324

Scott A. Pierce
Dennis J. Riechman
Warfighter Readiness Research Division
Logistics Readiness Branch

Jill Lindsey
Wright State University
3640 Colonel Glenn Highway
Dayton OH 45435

Norman Badler
Computer and Information Science Department
University of Pennsylvania
Philadelphia PA 19104

Adam Green
Betis Group, Inc.
7 Strawberry Street
Cape Charles VA 23310

January 2009

Final Report for July 2007 to January 2009

Air Force Research Laboratory
711th Human Performance Wing
Human Effectiveness Directorate
Warfighter Readiness Research Division
Logistics Readiness Branch
Wright-Patterson AFB OH 45433-7604

NOTICE AND SIGNATURE PAGE

AFRL-RH-WP-TR-2009-0060 HAS BEEN REVIEWED AND IS APPROVED FOR PUBLICATION IN ACCORDANCE WITH ASSIGNED DISTRIBUTION STATEMENT.

//SIGNED//
DENNIS J. RIECHMAN
Work Unit Manager
Logistics Readiness Branch

//SIGNED//
DANIEL R. WALKER, Colonel, USAF
Chief, Warfighter Readiness Research Division
Human Effectiveness Directorate
711th Human Performance Wing
Air Force Research Laboratory

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
January 2009

2. REPORT TYPE
Final

3. DATES COVERED *(From - To)*
July 2007 – January 2009

4. TITLE AND SUBTITLE
Anticipating Job Aiding and Training Requirements

5a. CONTRACT NUMBER
FA8650-04-D-6546 DO#09

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
62202F

6. AUTHOR(S)
[1]Patrick J. Vincent, [2]Scott A. Pierce, [2]Dennis J. Riechman, [3]Jill Lindsey, [4]Norman Badler, [5]Adam Green

5d. PROJECT NUMBER
7184

5e. TASK NUMBER
D2

5f. WORK UNIT NUMBER
7184D206

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
[1]Northrop Grumman Information Technologies
2555 University Boulevard
Fairborn OH 45324

[3]Wright State University
3640 Colonel Glenn Highway
Dayton OH 45435

[4]Computer and Information Science Department
University of Pennsylvania
Philadelphia PA 19104

[5]Betis Group, Inc.
7 Strawberry Street
Cape Charles VA 23310

8. PERFORMING ORGANIZATION REPORT

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
[2]Air Force Materiel Command
Air Force Research Laboratory
711th Human Performance Wing
Human Effectiveness Directorate
Warfighter Readiness Research Division
Logistics Readiness Branch
Wright-Patterson AFB OH 45433-7604

10. SPONSOR/MONITOR'S ACRONYM(S)
711 HPW/RHAL

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
AFRL-RH-WP-TR-2009-0060

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES
88 ABW/PA cleared on 18Jun09, 88ABW-09-2768.

14. ABSTRACT
The primary objective of this research effort was to gain a better understanding of current trends (demographic, workforce, technology, etc.) and challenges related to job aiding and training in order to develop the foresight needed to help formulate potential areas for future research. During the course of this effort, the scope of our research and investigations became specifically focused on Air Force *technical* training, which encompasses training for career fields such as Aircraft Maintenance, Medical, Civil Engineering, and numerous others conducted at various Air Force bases (as well as sister service bases) in the U.S. Although not specifically focused on during the research in the context of technical training, the topic of job aiding was still considered relevant to our research, since some of the same job aids used to directly support day-to-day operations and maintenance activities in the field, are also an integral part of technical training.

15. SUBJECT TERM Job Aiding, Training, Communication, Distributed Collaboration, Human-Computer Interface, Logistics, Virtual Teams

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Dennis J. Riechman
U	U	U	SAR	76	19b. TELEPHONE NUMBER *(include area code)* NA

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. 239.18

THIS PAGE LEFT INTENTIONALLY BLANK

TABLE OF CONTENTS

TABLE OF FIGURES

ACKNOWLEDGEMENTS

We would like to express our sincere appreciation to the personnel at HQ AETC, 2^{nd} AF, and in particular, the instructor and staff personnel at the 82nd Training Wing (82 TRW), Sheppard AFB, TX, particularly Ms. Gina Johnson, for their outstanding support and participation in workshop and research activities conducted as part of this effort.

THIS PAGE LEFT INTENTIONALLY BLANK

1.0 INTRODUCTION

The *Anticipating Job Aiding and Training Requirements* research effort was sponsored by the Air Force Research Laboratory's Logistics Readiness Branch (AFRL/RHAL) under Task Order #9 of the Technology for Agile Combat Support (TACS) contract (FA8650-04-D-6546). The period of performance for the research effort extended from 13 July 2007 to 12 January 2009. This report documents the technical effort and results of research activities conducted as part of this task order. The scope of these activities included the following:

- Reviewing relevant literature related review of current and future trends impacting the workforce, work environment, and technologies relevant to job aiding and training.
- Gathering information through telephone interviews with representatives of Air Force organizations involved in force development and training, as well as Air Force Career Field Managers responsible for establishing training requirements.
- Planning and conducting workshops focused on gaining a better understanding of the Air Force Technical Training environment, challenges, and future directions.
- Identifying and formulating potential future research vectors intended to better inform future programs, policies, and decisions impacting Air Force Technical Training.
- Conducting a pilot study of 21st Century learning and teaching styles in select courses conducted at the 82nd Training Wing (82nd TRW), Sheppard AFB, TX.

1.1 Objective and Scope

The primary objective of this research effort was to gain a better understanding of current trends (demographic, workforce, technology, etc.) and challenges related to job aiding and training in order to develop the foresight needed to help formulate potential areas for future research. During the course of this effort, the scope of our research and investigations became specifically focused on Air Force *technical* training, which encompasses training for career fields such as Aircraft Maintenance, Medical, Civil Engineering, and numerous others conducted at various Air Force bases (as well as sister service bases) in the U.S. Although not specifically focused on during the research in the context of technical training, the topic of job aiding was still considered relevant to our research, since some of the same job aids used to directly support day-to-day operations and maintenance activities in the field, are also an integral part of technical training. For example, Interactive Electronic Technical Manuals (IETMs) and Core Automated Maintenance Systems (CAMS) workstations are used to support certain course blocks/units of instruction in aircraft maintenance training courses. From this perspective, the job aids used are more properly classified as training equipment which was a consideration in the research.

1.2 Background

The Air Force faces many challenges in the future due in part to the changing nature of warfare (e.g. cyberspace), a changing workforce (e.g. loss of skilled workers) and an increasing operations tempo - fueled in part by the current War on Terror. Addressing these challenges puts

a strain on personnel and other resources, and adversely impacts budget outlays in numerous areas including system procurement, equipment refurbishment, research and development, and numerous others including technical training. With respect to education and training, the Air Force needs to develop a common vision for the future (Air Education and Training Command (AETC) Future Learning Board presentation, Sep 08) to help address some of these challenges, including devising a creative plan and systematic approach for adapting new strategies and methods for developing and conducting technical training, as well as for integrating or inserting new technologies that can help meet training objectives in a more efficient and cost effective manner.

2.0 STUDY APPROACH AND METHODOLOGY

The core research team for this effort was comprised of personnel (contractor and AFRL) representing several academic disciplines including operations research, human factors, education and training (including previous AF instructor experience), and computer science. The composition of the team allowed us to take a multi-discipline approach to the task of assessing and formulating potential research areas related to job aiding, education and training. The model or framework for conducting the research is portrayed in Figure 1. The research conducted as part of this effort commenced with a literature search and review of relevant publications and technical reports on factors (e.g. demographics, technology, etc.) impacting training, and in particular Air Force technical training. The intent of this investigation was to identify current and future trends in relevant areas and assess their importance to formulating future research vectors for job aiding and technical training. Interviews and discussions were conducted with personnel at HQ USAF, HQ AETC, 2nd Air Force, and the 82nd TRW at Sheppard AFB, TX to gain a better understanding of current policies and processes related to the selection, classification, and training of enlisted personnel, and future challenges in these areas.

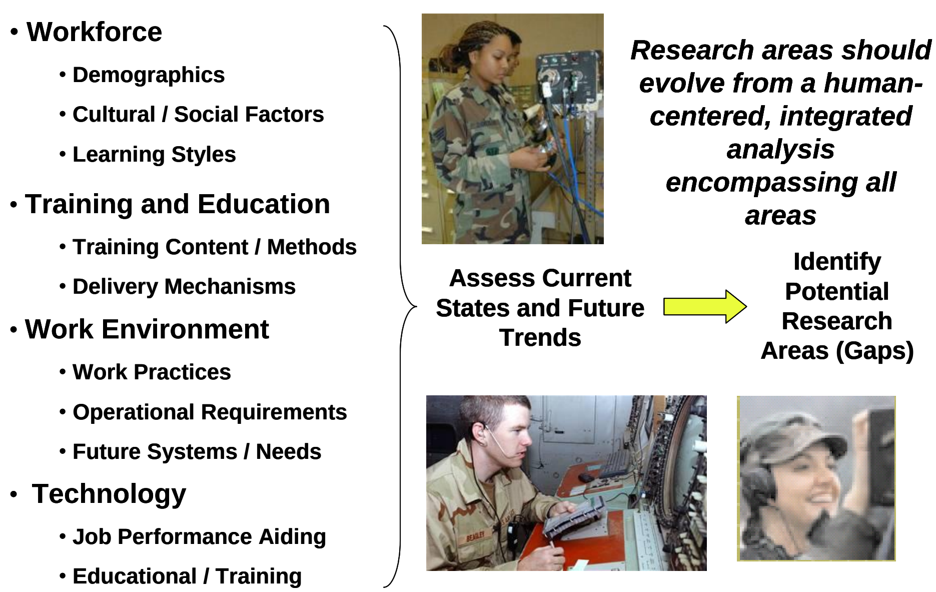

Figure 1: TACS DO-9 Research Framework

In addition to these activities, two workshops were planned and convened as part of the research effort. The first workshop was hosted and supported by the 82nd TRW at Sheppard AFB, TX in January 2008. The primary intent of this workshop was to gain a better understanding of the problem space as it pertained to the challenges associated with training future warfighters. A second workshop was convened at Wright State University in April 2008. This workshop brought together members of the core research team to discuss and identify potential areas and topics that future research efforts might focus on to help address challenges identified through the literature search activities and interviews with Air Force personnel, as well as observations and technical discussions at the initial workshop.

The final portion of the research effort focused on planning and conducting a pilot study to assess the learning and teaching styles of students and instructors, as well as the instructional methods used, in a select group of courses conducted at Sheppard AFB. The methodology, analysis, and results of this pilot study are documented in a separate report included in Appendix D and considered in the development of recommendations documented in this report.

3.0 RESULTS AND DISCUSSION

3.1 Literature Review and Interviews

3.1.1 Relevant Factors and Demographic Shifts

Three key factors are projected to have important effects on the workforce and work environment in the next 10 to 15 years. These factors include demographic shifts, technological advances, and global competition [Ref. 1], [Ref. 2]. In turn, these factors (collectively in some cases) are causing the skill and knowledge demands related to work to increase, and thus spurring the call for more rapid improvements in both primary and secondary education (grades K-12 and beyond), particularly in Science, Technology, Engineering, and Mathematics (STEM) curriculums. With respect to demographic shifts, current and future trends indicate that the growth rate of labor force is expected to slow to 0.6 percent in the 2010s and 0.4 percent in the 2020s [Ref. 3], [Ref. 4]. That is a sharp decline from the 1.3 percent average annual increases seen in the 1990s and the 2.6 percent average annual increases experienced during the 1970s. At the same time, the workforce grows older. In was estimated that over 50 percent of the workforce in 2007 was eligible to retire [Ref. 5], thus raising concerns about how to: a) replace or offset the loss of job knowledge and experience of those retiring, and b) retraining those in this category that elect to continue to work, but will need to learn and develop new skills in response to shifting job demands caused by a global economy and technological advancements. The workforce of the future is also expected to be more racially/ethnically diverse. One important question that comes into play as it pertains to Air Force recruitment and technical training is given these shifts, how do we change the way we recruit and train future warfighters?

3.1.2 The “Millennial” Generation

The American youth population, ages 16 to 21, is the primary recruiting market of the Armed Services, and their characteristics have been changing over time. Gradual changes are occurring in the racial/ethnic composition of this population, as well as their educational and career aspirations. Almost all youth (88 percent) report they plan to continue schooling and

obtain higher education of one form or another. The number of high school graduates and the number of youth completing some college is increasing steadily. However, as the number of high school graduates going on to attend college increases, the cost of a post-secondary education has also increased dramatically [Ref. 6].

. The youth comprising this population are part of the "Millennial" generation - a generation that includes over 75 million Americans born between 1982 and 2000 (circa). This means current and future (at least for several years) recruitment and training efforts in the Air Force (as well as sister services) will be targeted towards individuals representing the Millenial generation. Some key characteristics of Millenials include the following:

- Technologically savvy
- View technology as permeating every aspect of their lives
- Racially and ethnically diverse
- Identify with their parents values and feel close to their parents
- Rely heavily on collaboration with peers as a form for learning
- Learning needs to be hands-on, interactive, collaborative, and fun
- Need for on-going learning

The learning preferences (or learning style) of Millenials favor teamwork, experiential activities, structure, and technology and their learning strengths include multi-tasking, goal orientation, a collaborative style, and positive attitudes [Ref. 7]. In addition, there is mounting evidence that Millenials have a different relationship with information and learning than those from previous generations, primarily due to their access to the Internet and computer-enabled technologies [Ref. 8]. Arguably, one potential drawback of this access to technology is that Millenials, by age 21, tend to spend significant less time reading - less than 5,000 hours - and more time with activities such as playing video games or talking on a cell phone – equally divided, around 20,000 hours [Ref. 9].

From a training perspective, the characteristics, learning preferences, and technology driven traits of Millennials cited above should be important considerations in the design, development and delivery of technical training, including the insertion of training technologies into course curriculum. However, to our knowledge, no direct consideration or recognition to individual learning styles is given in course development processes such as the Instructional System Design (ISD) process that has long been used by the Air Force to develop training courses.

3.1.3 Technical Training Challenges

The Air Force continues to face many training challenges due to a) an increased operational tempo associated with supporting on-going contingency and wartime operations abroad; b) budgetary and force reduction pressures; and c) transformation initiatives such as Air Force Smart Operations 21st Century (AFSO21), Maintenance Training Enterprise 2010, and Virtual Training Record that evolved from the eLog-21 program. Some of the key challenges for Air Force training include the following:

- Reduced budgets for providing training, including manpower, training equipment, and other resources
- Reduction and consolidation of Air Force specialties
- Increased pressure on mid-level and senior enlisted supervisors to fill the “voids” in technical training that cannot be addressed in initial skills training at AETC formal training schools. The increased demands associated with supporting operations in Iraq and Afghanistan afford less time for training in the field
- Increased need to reduce training time and get personnel to the field with the initial skills they need to perform effectively in their respective jobs
- Loss of skilled personnel due to an aging workforce and personnel retiring or exiting the Air Force
- Reducing course “washback” (repeating blocks of instruction) and attrition rates in select courses

In reference to the last bullet concerning course attrition and washback rates, it is worth noting for this research that a snapshot assessment of these rates in the last calendar year quarter of 2007 indicated that for the 82nd TRG at Sheppard AFB, TX, 32 percent of initial skills courses reported “high” (above programmed goals) attrition, and approximately 50 percent of courses had washback rates exceeding 16 percent. These factors are significant, considering that the average cost for initial skills training in the Air Force exceeded $47,000 per trainee in FY 07, with training for some career fields like crypto linguists exceeding $100,000 (Source: AFI 65-503, Table A18). Figure 2 identifies technical training courses in 2nd AF (including Sheppard AFB) that had high attrition or washback rates that exceeded 20 percent in FY07 (only courses with 50 or more students were considered in the analysis). The rates shown were compiled from data in the Technical Training Management System (TTMS) for FY07. A subset of these courses was investigated in Air Force sponsored RAND study that will be addressed later in this report.

ELIMINTATIONS	GOODFELLOW		
COURSE	TITLE	50 + COUNT	20% + RATE
XBAQZ1N335A0ADA	Arabic Basic	52	288.89%
X3ABR1N031 0A6A	Operations Intel Apprentice	113	21.52%

WASHBACKS	GOODFELLOW		
COURSE	TITLE	50 + COUNT	20% + RATE
XBABR1N531 0A1A	Electronic Signals Intelligence Exploitation	56	81.16%
X5AQZ1A831KP040	Airborne Linguist, Korean Basic **(Disc)**	73	24.50%
XBOVZXXXX 0ADA	Arabic Basic	78	96.30%
X5AQZ1N334G 041	Far East Crypto Linguist Apprentice, Korean **(Disc)**	203	27.88%
XBAQZ1A831D0KPA	Airborne Korean Basic	224	29.83%
XBAQZ1N335A0ADA	Arabic Basic	497	24.58%

ELIMINTATIONS	KEESLER		
COURSE	TITLE	50 + COUNT	20% + RATE
E3ABR1C131 00RB	Air Traffic Control Radar Apprentice	54	21.77%

WASHBACKS	KEESLER		
COURSE	TITLE	50 + COUNT	20% + RATE
E3ABR1C131 00TB	Air Traffic Control Tower Apprentice	52	25.00%
E8ABR1W031 1A1B	Aerographer's Mate Class A1	61	29.90%
E3AQR2E633 0E2B	EP, Telephone & Switching Systems	63	22.34%
E3AQR2A533A048B	EP, Communications/Navigation/Mission Systems	112	21.62%
E8ABR1W031 0A1A	Weather Forecaster Apprentice	121	31.35%
E3ABR1C131 00RB	Air Traffic Control Radar Apprentice	148	37.37%
E3ABR2E231 01ZC	Network Infrastructure System	188	30.23%

ELIMINTATIONS	LACKLAND		
COURSE	TITLE	50 + COUNT	20% + RATE
LCAQP1XXXX 01OA	Air Force Combat Dive Course - Open Circuit	54	37.50%
L3AQR1C231 0C0B	Combat Control (Prelim)	101	45.29%
L3ABP1C431 0T0A	Tactical Air Command & Control Apprentice	108	40.45%
L3AQR1T031 0S0A	Survival Evasion Resistance Escape (Prelim)	137	52.09%
L3AQR3E831 0E0B	Explosive Ordnance Disposal (Prelim)	148	52.11%
L3AQR1T231 0P1A	Pararescue Indoctrination Course	163	57.60%

WASHBACKS	LACKLAND		
COURSE	TITLE	50 + COUNT	20% + RATE
L3ABR2T031 00AA	Traffic Management Apprentice	81	19.90%
L3ABP1C431 0T0A	Tactical Air Command & Control Apprentice	115	30.10%

ELIMINTATIONS	SHEPPARD		
COURSE	TITLE	50 + COUNT	20% + RATE
JBAQN3E831 00NA	Explosive Ordnance Apprentice	50	38.17%
J8ABR4A231 20AA	DoD Biomedical Maintenance Equip Tech	57	50.89%

WASHBACKS	SHEPPARD		
COURSE	TITLE	50 + COUNT	20% + RATE
J8ABR4A231 00AA	DoD Biomedical Maintenace Equip Technician (AF)	53	43.09%
J3ABR2A631E050B	Aerospace Propul Appr Jet Eng (F110) (MRT)	56	23.83%
J3ABR2A631C048B	Aerospace Propul Appr, Jet Eng (TF33, TF34, F-108)	72	21.88%
J8ABR3E131 00AB	HVAC & Refrigeration Apprentice	76	24.68%
J3ABR2A636 0A9B	Aircraft Elect & Environmental Systems Apprentice	122	19.65%
JBAQN3E831 00NA	Explosive Ordnance Apprentice	128	49.42%
J8ABR4A231 20AA	DoD BiomedMaint Equipment Technician (Army)	221	65.00%
J3ABR2A632 046B	Aerospace Ground Equipment Apprentice (AGE)	257	30.96%
J3AQR4N031 01AB	Aerospace Medical Service Apprentice - Phase 1	1,093	44.27%

Includes performance, academic and medical washbacks and eliminations

Figure 2: 2nd AF Washbacks/Eliminations (FY07)

The Air Force is investigating ways to streamline training and address some of the challenges outlined above. For example, the *Maintenance Training Enterprise Value Stream Mapping* project, started in early 2006, is an AFSO-21 initiative intended to help streamline the Air Force technical training process by leaning out inefficiencies and redundancies in the process and viewing training from a "life-cycle" perspective. Based on discussions with a few Air Force Career Field Managers, two of the more significant questions that might be addressed in future research include 1) how can we best leverage technology to innovate and streamline training?; and 2) how do we address the impact of an aging workforce and loss of skilled technicians to train future warfighters? There was also some recognition of the need to better understand the learning needs and styles of future warfighters (Millenials), to better understand how we can best leverage technology, and adapt selection and placement processes/tools, to meet their learning needs as well as the needs of the Air Force.

3.1.4 Future of Air Force Education and Training

One of the more significant papers reviewed included a HQ AETC White Paper released 31 Jan 2008 titled *On Learning: The Future of Air Force Education and Training* [Ref. 10]. The paper is intended to articulate concepts the AF should consider adopting to train and educate future Airmen - the Millennials or 21st Century Learners. These concepts include Knowledge Management, Continuous Learning, and Precision Learning. Some of the key assumptions that underpin the concepts and recommendations presented in the plan include the following:

- The Air Force will innovate and change its approach to education and training in order to effectively prepare future Airmen to perform successfully.

- New approaches to education and training will account for how future Airmen learn, as well as changes in technology, and the future environment in which Airmen operate.
- Future enterprise-wide learning systems will access comprehensive, authoritative data and information and will be widely accessible, highly reliable, and robustly protected.
- An integrated and systematic approach to improving the quality and delivery of the learning experience will focus and leverage current and future education and training initiatives.
- To lead-turn adversary learning, the Air Force will be an early tester and adopter of new, innovative learning approaches and technologies or risk falling behind.
- Knowledge-enabled Airmen will continue to be the key to flexibility and the Air Force's asymmetric military advantage in air, space and cyberspace.

Numerous recommendations are proposed and discussed in the paper to help achieve the proposed to realize the vision of "delivering unrivaled air, space, and cyberspace education and training." One of the key recommendations, relevant to this research task, is the development of MyBase, a virtual environment (world) based on research and software developed by San Francisco based Linden Research and launched in 1993. MyBase is currently a set of regions or islands in Second Life devoted to sharing Air Force history and learning about the Air Force, however current interest and endeavors are focused on evolving MyBase as an environment and foundation to support future Air Force education and training initiatives (with limits). As of Spring 08, efforts were focused Marketing of white paper and drafting implementation plan to support vision and recommendations. Some of the key points of interest for the DO-9 research effort expressed directly or indirectly in the paper included:

- "Precision identification of viable recruits using advanced aptitude and skill assessment tools." This implies new or better methods and tools beyond the currently administered Armed Services Vocational and Aptitude Battery (ASVAB) test that is used to inform career field placement decisions
- Too much batch processing – need new concepts that recognize people learn differently and at different paces
- "Delivery of training must be flexible and must permit schedule, delivery and media formats tailored to individual needs"
- "Determine which technologies are essential" to the concepts and "learning vision" put forth in the white paper
- "Learning experiments" that encompass "tests of various combinations of virtual, live, constructive training approaches to evaluate optimal mixes of technology, organizations, and learning concepts"
- Paper advocates "a program for learning research and development, and insertion of technologies into training and education programs"

3.2 Workshop #1

The initial DO-9 workshop was convened at the 82nd TRW, Sheppard AFB, TX from 30 January 2008 to 31 January 2008. This purpose of this workshop was twofold: 1) to gain a better understanding of the technical training environment at Sheppard AFB; 2) to identify additional

questions we still need to address and information we need to acquire to help better formulate and articulate future research needs as it pertains to technical training. The format and specific topics covered at the workshop are covered in detail in Appendix A and included multiple subject area/topic presentations (e.g. field evaluation and training process), course observations, a group interview and panel discussion with instructors, and DO-9 working group discussions on information collected at the workshop. This initial workshop was of tremendous value to the DO-9 task in helping to familiarize research team members with the overall technical training process and environment, as well as providing insight to some of the challenges associated with training future warfighters. Of particular interest was the feedback received from instructors who participated in the panel discussion at the workshop. A short questionnaire was developed to help facilitate this discussion (see Appendix B). Areas of primary interest highlighted by instructors during the panel discussion included the following:

- "Hands-on" training critical to some courses (e.g. maintenance) this is what gets the students excited
- Quality of Trainees (skills and motivation to study / learn lacking for some students)
- Remedial Training Needed (in some courses – e.g. handtools)
- Instructor additional duties / taskings can be a distraction to training
- See cycles of "good" students (some college) and poorer students
- Some language barrier problems
- Instructor manning levels - not always optimal, and additional duties for instructors (and trainees) outside of class can be personnel "stressors"
- Funding for training equipment / trainers / etc.
- Pressures to reduce training time and get proficient airmen to the field quicker

In addition to the panel discussion, the instructor questionnaire (Appendix B) was also posted on the 82nd TRW Community of Practice so that instructors not participating in the workshop could have an opportunity to respond. A total of 60 responses were received from instructors representing multiple courses conducted at Sheppard AFB. The range of instructor experience extended from six months to 13 years, with an average instructor experience level of around three years. A summary of the responses to each of these questions is provided in Appendix C. Overall, the responses received from this group of instructors confirmed some of the same themes and challenges cited above from the panel discussion, in particular, the importance of "hands-on" training, shortage of instructors and impact of instructor additional duties on workload, as well as the condition of training equipment and funding for equipment maintenance and procurement of new equipment.

Members of the research team convened a separate working group session at the workshop to discuss the information presented at the workshop, including general impressions from classroom observations in select courses. The intent of this session was to try and identify some key needs or areas of focus that should be considered in the process of formulating future research vectors as part of the second workshop. Some of the ideas and general impressions discussed during this session included the following:

- Examining current processes and procedures for training instructors in terms of the time required to produce qualified instructors which can now take up to nine months.

- Developing better policy and guidelines, and collect data (once defined), to help us downstream better understand the effective and efficient use of technology – where is it warranted, what type of technology, and the return on investment.
- Conducting experiments to better understand where technology works and doesn't work in terms of improving training and learning outcomes.
- Gaining a better understanding of who our "learners" are and how they learn.
- Investigating better methods/tools to assess and "pre-train" for the requisite skills/knowledge in the assigned career field.
- Identifying the relationship between training "attributes" and the acquisition of training technologies – there seems to be very little data / research on this topic.
- Gaining a better understanding of how students succeed (or fail) in the training that is currently provided. For those that are not so successful, what can be provided to help them have a better chance to succeed?
- There seems to be a need to collect more relevant course data on students who graduate and those who do not due to academic or other reasons (attrition). What were their profiles like? Are there leverage points that we might learn from and exploit to design future training or bring to bear in the near term?
- Some concern about how much it appeared policies and procedures seemed to stifle (impede) innovation as it applies to improving training. Also, the mental mindsets that seemed to be formed around (influenced by) the organizational culture.
- A need to focus on "output quality" as it relates to training, which may not necessarily be tied to training budgets/funding as it appears now. This relationship is important to understand and should be actually scrutinized by the leadership. For instance, if the quality of airmen graduating improved, would it offset the emphasis on funding? Main point is quality versus funding – we need to better understand the relationship.
- Gain a better understanding course attrition and washback rates in terms of root causes. *Note: During the timeframe of the DO-9 research effort, a HQ USAF/A1PF sponsored RAND study titled "Enhanced Testing and Screening" was ongoing that, in part, was focused on looking at schoolhouse attrition in select courses. Data collected as part of that study may be helpful for providing more insight into root causes for attrition/washback rates.*

3.3 Workshop #2

The information gathered during the initial workshop, as well as the ideas generated and general impressions discussed in the working group session were carried forward for consideration in a second workshop convened at Wright State University in late April 2008 and included members of the DO-9 research team (AFRL and contractor). The team reviewed the information collected in the first workshop as well as additional information and data collected after the first workshop, and focused on developing a framework for identifying and discussing potential areas for future research as it pertains to technical training. It was clear from the discussions and findings at the first workshop that some of the training challenges and needs identified are significantly impacted by factors that will most likely not be resolved or addressed through research alone. Budgetary constraints (e.g. replacing or upgrading training equipment, trainers), current operational tempo (e.g. pressure to increase throughput of students to support

on-going operations), and current organizational and training policies and procedures, are factors that also need to be considered as part of formulating a future research agenda for technical training.

With this in mind, members of the research team proceeded to develop a framework for discussion of research that attempted to address the various components or facets of training that were subsequently labeled as training dimensions (see Fig. 3). The training dimensions identified include: *methodology* which deals primarily with instructional methods, but also the design and development of course curriculum; *technology* which encompasses the software, hardware, and infrastructure used to develop and deliver training; *learning environment* which considers classroom layout and environmental factors, the structure of the day in terms of classroom and outside activities/duties, etc.; the *learner*, including their learning preferences/styles, abilities, motivation, etc.; the *instructor*, including the quality of their training, expertise, attitudes toward use of technology, etc; and finally, *evaluation* which encompasses the policies, methods, tools, and metrics used in assessing training, including learner and instructor performance, training methods, and training technologies. It is important to note a) that these training dimensions are not independent, and in fact any one dimension may have multiple points of intersection with others in future research; and b) collectively, these dimensions should all be focused on supporting the goal of learning. The framework depicted in Figure 3 is representative of the perspective the DO-9 research team took to further identify specific attributes for each training dimension that were considered important to developing research "vectors" for each training dimension. The discussion of each of these vectors that follows is not intended to identify specific research tasks or products, but rather focuses on highlighting potential questions and issues that should be considered in formulating a research agenda for technical training.

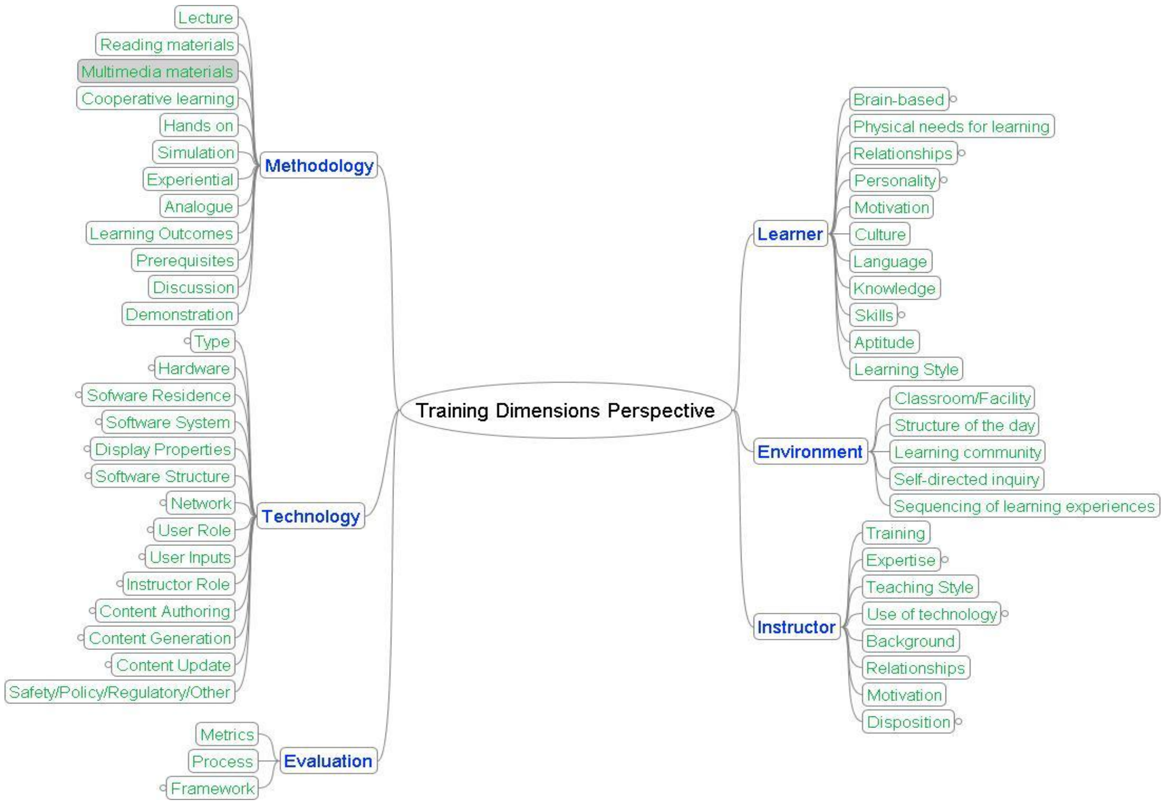

Figure 3: Training Dimensions Perspective and Attributes

3.3.1 Learners

This research vector focuses on understanding how applying knowledge about learners, both individually and collectively, could improve the efficiency and success of technical training. Trainees' experiences and needs as learners must be understood and optimized in the technical training environment. The *"Human Behavior in Military Contexts"* book (section dealing with technology and training and discussed earlier) concluded that first and foremost "training programs should be based on an understanding of how people learn and how instructional methods affect learning." [Ref. 11]

Research is needed to better understand the role of learners' needs and individual differences; most specifically those attributes, learning preferences (discussed in the pilot study conducted as part of the DO-9 research effort and included in Appendix D), pre-requisite knowledge and skills that contribute to success or failure during technical training. Such knowledge about learners could then inform the redesign of technical training so as to improve learner engagement, comprehension, and successful completion of training. This research has the potential to yield both short and long term impact by identifying areas for immediate intervention via training modifications or redesign, as well as identifying areas where developing future technologies may improve outcomes.

This research vector would explore technical training through the lens of learners' needs and experiences. This dimension of inquiry will focus on understanding the relationships between learners' physical, psychological, social, and cognitive needs, and the structure and

context of training. A specific subset of this research will investigate the impact of interactions between individual learners' attributes, pre-requisite knowledge and skills, preferred learning modalities, and instructional methods on training performance. The learner vector of research has the potential to uncover leverage points of intervention to reduce training time while improving the quality of learning and graduation rates.

Research in psychology, biology, linguistics, and neurophysiology inform our understanding of the human brain and learning, and provide a foundation for exploring how learning in technical training environments can be improved. The following examples are provided to illustrate research opportunities in this vector.

- Current research on the plasticity of the human brain suggests that learning impacts brain chemistry, reinforcing neural connections through practice. Cognitive functions involve the simultaneous interactions of whole concepts and whole images, similarities, differences, and relationships. The brain works by analogy and metaphor, and does not assemble thoughts by bits of data. How might technical training be redesigned to optimize these ways in which the brain works?
- Human learning psychology research suggests that metacognition, thinking about your thinking, is a vital component of comprehension, self-regulation, and motivation. How might metacognition be incorporated into technical training to optimize motivation and learning?
- New research on multi-tasking suggests that learning is impaired by activities that distract a learner's attention from the primary focus of comprehending new information. How might this understanding inform the selection of instructional methodologies in the technical training environment?
- Recent research on the relationship between exercise and cognition suggests that movement of our muscles produces proteins that play a pivotal role in higher level thinking and learning. How might this understanding of the relationship between exercise and brain function influence the way we schedule the training day?
- Human learning is an essentially social endeavor. Relationships with peers and instructors contribute to or distract from learning. How might this understanding of the role relationships play in learning guide training methodology?
- Every learner brings their unique personality and life experiences to the training context. Individual attributes, such as; aptitudes, personality characteristics, learning preferences, and predispositions, contribute to success or failure in training. If we better understood the role individual attributes play in a learner's success, how might training be redesigned to better meet individual trainees' learning needs?
- Over 40 years ago, Vygotsky said "culture is cognition," suggesting that how we think is based upon our culture and our language. The culture of the 21st Century is impacting language and cognition. The necessary components of learning in the 21st century are not those focused on in the past. Digital age literacy, inventive thinking, effective communication, and high productivity must be included in future learning context. How might technical training be redesigned to optimize this shift in culture and cognition?
- Human learning is essentially constructive; learning builds on a learner's prior knowledge and skills. When the necessary prerequisite knowledge and skills are not in place, learning is sabotaged. How might training be more efficiently accomplished

is each trainee was equipped with the necessary prerequisite knowledge and skills, through screening processes and or remediation?

From these examples, it is clear that the "Learner" vector offers a rich potential research agenda, and it intersects with the other potential vectors described in this report. Learners are the sine qua non of learning, and every training endeavor must begin and end with meeting learners' needs if technical training is to be efficient and effective.

3.3.2 Instructors

This research vector focuses on understanding the role of the instructor, instructor preparation, instructor professional development, and instructional modifications that could improve the efficiency and success of technical training. This vector intersects with the "Learner" research vector from the standpoint that instructors must understand and draw on trainees' experiences and needs as learners in order to "optimize" student learning experiences in the technical training environment.

Research is needed to better understand how instructors and instructional methods contribute to success or failure during technical training. Such knowledge about instructors and instruction could inform the redesign of technical training so as to improve learner engagement, comprehension, and successful completion of training. As with the "Learner" research vector, research into instructors and instruction has the potential to yield both short and long term impact by identifying areas for immediate intervention via instructor training modifications or redesign, as well as identifying areas where incorporating future technologies into instruction could improve learning outcomes.

This research vector should also explore technical training through the lens of the instructor's preparation and practice. This dimension of inquiry will focus on understanding the relationships between instructor preparation/practice and student performance in technical training. One subset of this research could investigate the impact of instructor selection and preparation. Another subset of research could lie in examining the interactions between instructors and individual learners' preferred learning modalities, and selection of instructional methods as they impact training performance. The instructor vector of research has the potential to uncover leverage points of intervention to reduce training time while improving the quality of learning and graduation rates.

This vector is interwoven with the "Learner" vector in that research in psychology, biology, linguistics, and neurophysiology inform our understanding of the human brain and learning, and provide the foundation for exploring how learning in technical training environments can be improved. Instructor preparation and professional development could incorporate information about improving human learning to optimize student success. The following examples are provided to illustrate research opportunities in this vector:

- What knowledge about human learning needs to be included in instructor preparation to optimize student motivation and learning?
- How might current research about multi-tasking inform the selection and application of instructional methodologies in the technical training environment?
- How might the relationships between instructors and learners be optimized to improve learning?

- How might instructor preparation be redesigned to better meet instructors' learning needs and better prepare them to meet individual learner's needs in training?
- How might instructor selection and preparation be redesigned to expedite instructor readiness?
  - What preparation must instructors receive in order to incorporate digital age literacy, inventive thinking, effective communication, and high productivity into their instruction?

From these examples, it is clear that the "Instructor" vector offers a rich potential research agenda, particularly as it intersects with the "Learner" vector described earlier. Research suggests that instructors are the most influential variable in learning. Improving instructor preparation and practice is one of the most promising avenues to making technical training more efficient and effective.

3.3.3 Methodology

This research vector focuses on investigating and extending current methods and practices associated with the design and development of Air Force technical training courses for advanced learning environments such as those that encompass the use of virtual reality, avatars, serious games, and interactive simulation technologies [Ref. 12]. The overall objective of the research would be to improve our knowledge and understanding of the implications (emphasis on human perspective) of advanced learning environments in order to better inform methodologies supporting the design, development, and evaluation of Air Force technical training courses. The primary goals of this research would focus on improving the overall quality of training in advanced learning environments and reducing training costs.

Technology is being rapidly infused into development of training systems and applications at a rapid pace – a pace that far exceeds the introduction of new educational paradigms and instructional models/methodologies that provide insight on how to best harness the advanced capabilities these new technologies afford for the purpose of education and training. For the most part, traditional pedagogical methods are still in use to design, develop and deliver education and training. The question is how well suited are these traditional methods are for supporting training and education in advanced learning environments? In what manner do methods need to change to support training in these environments?

The scope of the research encompassed by this vector also includes the analysis of training requirements, development of training objectives, curriculum design, identification and selection of instructional methods, and instructional material development. The research should be focused on identifying and addressing shortfalls in the long-standing (circa 1965) Instructional Systems Development (ISD) process which is the official Air Force process for determining training requirements and developing education and training courses for Air Force personnel (see AFH 36-2235, Volume 9). Potential research questions that might be addressed as part of this vector include the following:

- What types of interdisciplinary skills are needed to support the design, development, and evaluation of these advanced learning environments?
- How well suited are current instructional methods and strategies for promoting learner success in advanced learning environments?

- What type methods and authoring tools are needed for developing and updating instructional materials (content) in advanced learning environments?
- How well are the technologies underlying advanced learning environments aligned with particular pedagogical principles, theories, models, hypothesis, or intuitions? [Ref. 12]
- What is the impact of advanced learning environments on learning and retention for a growing SLD (specific learning disabilities) population with dysgraphia, dyscalculia, dyslexia, dysnomia, memory & processing issues? Same question for a more culturally diverse population of learners?
- What do we know about the social / cultural needs and learning styles of future Air Force trainees (Millennials) that can be leveraged to better inform the design and development of technical training courses (particularly the development or authoring of content and selection of training technologies)?
- How relevant are existing instructional design methods or processes such as the Air Force ISD process for designing and developing course curriculum and instructional materials for training in virtual and collaborative learning environments? What shortfalls exist in current instructional design methods or processes for these environments?

The methodology vector intersects with other research vectors discussed in this report, particularly the learner, evaluation, instructor, and technology vectors. Processes like ISD must somehow take into account the knowledge, skills, abilities, and needs of individual learners. These factors (or attributes) are addressed to some extent in the research outlined for the learner vector, particularly from the standpoint of gaining a better understanding of how these factors impact training performance. Research proposed for the evaluation vector dealing with metrics and methods for evaluating advanced training environments will help inform the development of new strategies and methods for designing and developing instructional materials for technical training courses. Research discussed as part of the technology vector dealing with understanding the limitations of new technologies (hardware and software) that underpin advanced learning environments from both a human and technical perspective will help better inform the process of selecting and designing instructional materials (content), as well as in selecting the "best" method for delivering technical training courses to trainees (e.g. in advanced distributed learning environments). This will be extremely important to consider in light of the proposed Air Force MyBase concept discussed earlier in this report that seeks to leverage existing virtual environments like Second Life for developing future training.

3.3.4 Evaluation

This research vector focuses on exploring and applying evaluation resources to support the development of criteria for evaluating technology applications in training. Technology applications must enhance trainees' experiences and address their needs as learners in order to optimized learning in the technical training environment.

Research is needed to develop and test evaluation criteria to guide decisions about technology applications in training based on learners' needs, the development of required knowledge and skills, motivation, and engagement as contributors to success or failure during technical training. These criteria could then inform the redesign of technical training so as to

improve learner engagement, comprehension, and successful completion of training. This research has the potential to yield both short and long term impact by identifying immediate applications of evaluation criteria and processes to inform training modifications or redesign, as well as identifying areas where applying evaluation criteria to future technologies may improve learning and performance outcomes. In addition, this vector of research would focus on understanding the relationships between technology applications, instructor expertise, and learners' physical, psychological, social, and cognitive needs in the context of training. The evaluation vector of research has the potential to guide decision-making related to technology applications so as to reduce training time while improving the quality of learning and graduation rates.

Given the importance of evaluation to guide decision-making, it is vital to have a framework of standards for planning and judging the validity of any evaluation. Fortunately, such a framework has been developed by the Joint Committee on Standards for Educational Evaluation. This framework has been adopted by several professional associations, including the American Association of School Administrators (AASA) , the American Counseling Association (ACA), the American Educational Research Association (AERA), the American Evaluation Association (AEA), the American Psychological Association (APA), the Canadian Evaluation Society (CES), the Canadian Society for the Study of Education (CSSE), the National Association of Elementary School Principals (NAESP), the National Association of Secondary School Principals (NASSP), the National Council on Measurement in Education (NCME), and the National Education Association (NEA). This framework identifies thirty standards divided into four subcategories: utility standards, feasibility standards, propriety standards, and accuracy standards. These standards can be used as a tool for evaluation planning, and as a set of criteria by which any evaluation can be judged.

Efforts or tasks associated with identifying existing evaluation resources, interpreting them for use, developing new evaluation criteria specifically for technical training contexts, and testing the usefulness of evaluation criteria in the field are the kinds of endeavors that should be considered as part the Evaluation research vector. Two examples are provided to illustrate research opportunities as part of this vector:

- Guskey's five-levels for evaluating professional development include: 1) Participants' reactions, 2) Participants' learning, 3) Organization support and change, 4) Participants' use of new knowledge and skills, and 5) Student learning outcomes. How might this existing model of evaluation for training inform the development of specific criteria to evaluate technology applications in technical training? [Ref. 13]
- *An Educator's Guide to Evaluating the Use of Technology in Schools and Classrooms - December 1998* was developed for the U.S. Department of Education by the American Institutes for Research in conjunction with its formative evaluation of the Technology Literacy Challenge Fund. The guide represents a joint effort among the Office of Educational Research and Improvement, the Office of Educational Technology, and the Office of Elementary and Secondary Education. An approach to developing an evaluation is provided focusing on identifying goals, indicators, benchmarks, measures, and gathering evidence. How might these guidelines inform the development of an evaluation process for technology applications in technical training?

This vector intersects with the Learner, Instructor, Curriculum, and Technology research vectors, in that research in these areas inform our understanding of the components of effective technical training; human learning, relationships between instructor and learner, content, and human responses to various levels of complexity in technology applications. These aspects of training offer insight into the kinds of criteria needed to determine the effectiveness of technology applications in technical training environments. Even though the dominate goal of technology applications in training is to increase various aspects of student learning and, in some cases, instructor performance; many variables contribute to whether the use of a particular technology application meets this goal. Contributing factors related to these other research vectors influence evaluation criteria. Important evaluation questions may be precursors to determining the impact on student and instructor performance of a given technology application, for example: (a) was enough technology available, and/or was access sufficient enough to potentially make a difference in performance? (b) were instructors adequately trained to use the technology provided and (c) were technology applications appropriately supported/integrated by the curriculum?

The ideas and questions presented above are just a few examples of how the Evaluation vector could be explored. This vector offers a potentially rich research agenda, especially at the intersection with other research vectors described in this report. Criteria for evaluating technology applications in training are essential to ensure that technical training is as effective and efficient as possible.

3.3.5 Environment

This research vector focuses on better understanding the role of the learning environment both inside and outside the classroom, including factors that contribute to student stress, and formulating recommendations for modifying institutionally related processes, practices, and policies that could improve the efficacy and success of technical training.

Research is needed to better understand the dynamics of the learning environment and how the interaction between students, instructors, delivery modalities, and the communication climate affect learning and knowledge transfer. Insight into the in-residence learning environment could give schoolhouse leadership, career field managers, and curriculum designers a better perspective on this generation's students. This research has the potential to yield both short and long term impact by identifying environment related shortfalls that could be addressed through immediate or near term interventions. Examples include examining the length and structure of the duty day for technical training including the sequencing of course instruction and other activities that reduce instructor/student stress and workload.

This vector is interwoven with all other training dimensions. The learning environment is fluid and self-generating, based upon curriculum delivery method, selected technologies, learner behavior, motivation, and knowledge, and instructor experience and attitude. This presents a challenge to researchers attempting to study this aspect of learning because a "learning environment" is comprised of ''all of the physical surroundings, psychosocial or emotional conditions, and social or cultural influences'' present in a learning situation [Ref. 14]. Therefore, research in this area could quite naturally focus on the intersections between the training dimensions that shape the learning environment. Such a holistic approach would serve to highlight those points at which Millennial students, military indoctrination, instructor quality, prerequisite knowledge, societal norms, game-influenced neurophysiology, and institutional

goals are at tension. The following examples are provided to illustrate research opportunities in this vector.

- What types of communications climate exist in a “typical” tech training class? What is the level of instructor-student interactivity? What are the norms for verbal, non-verbal, and para-verbal communication? Is there a generational trend?
- How does the institutional goal of “military indoctrination” affect the learning environment? What coaching practices might be implemented to create an environment that is disciplined without being oppressive?
- Is the institutional investment in the training environment – e.g. modern technology, hard trainers are well maintained and fit for purpose, facility upkeep – in consonance with the “valuing” of the students as Air Force members doing an important job.
- How does the extended duty day affect student learning and cognition? What schedule or task changes could reduce student stress and enhance attention, participation, and performance?
- How do instructors treat poor performing, female, or minority students? Are these students encouraged to ask questions; do they receive positive support? Do instructors call students by name? What techniques do instructors use to elicit student feedback?
- Does the curriculum and instructor behavior encourage investigation and risk taking? Are students allowed to “fail-to-success” as part of the instructional process?
- Is the physical classroom environment conducive to learning? Does each student have enough space? Are there physical, sensorial, or other environmental factors that inhibit learning?
- Does the students’ living environment and off-duty time management choices affect their retention and performance?
- Are high-performing or pre-qualified (e.g. technical college or an experienced tradesman) students encouraged to actively share their knowledge in the class? Do instructors properly leverage these students to motivate and assist poor performers?
- Are expectations for intra-student support, study groups, and other mutually beneficial learning behaviors clearly differentiated from cheating? Are individual or group performance tests more meaningful in a technical training environment than “closed book multiple choice” tests? [The relevancy here is that AETC schools hector students from the first day about cheating. In the “real Air Force” there is no such thing as a “closed book” task – tech data is mandatory and failure to use it is a punishable offense.]

From these few examples, it is clear that the Environment vector offers a rich potential research agenda, and it intersects with the other potential vectors described in this report. The student environment should be supportive and effective for learners of varied capabilities, social skills, and prerequisite knowledge. Research into this dynamic factor in the learning experience may illuminate simple changes to practices and policies that, while rooted in culture and tradition, fail to produce a mission-capable warfighter.

3.3.6 Technology

This vector is focused on developing a better understanding of the relationships between the use of technological “tools” (hardware and software), students, and their instructors. Technology itself is a broad area and encompasses several attributes that are pertinent to training (e.g. hardware, software, networking, etc.), so while the discussion in this section is fairly extensive, it is limited to topics and questions that were considered to be within the scope of potential research interest to AETC and AFRL.

The approach here is first to summarize various technology attributes and comment on the impact those attributes may have on learners and instructors. These technology attributes also precipitate various evaluation issues. Finally, there are some research questions which arise that are related to the individual learner, instructor, or evaluation issues, or are suggested by the interrelationships between these.

- The *technology types* considered are hard (physical) versus soft (computer-based) systems.
    - For learners, hard trainers have the advantage of physicality but a limitation of specificity. Soft trainers promote a variety of experiences, allow interactive guidance, and exercise abstract reasoning processes.
    - For instructors, hard trainers promote fixed lesson plans, hands-on training, but have the limitations of being dated and difficult or costly or even impossible to maintain (such as a complete aircraft). Software trainers are often rigid (limited options or lessons) or brittle (unexpected failures or bugs), and difficult to modify or update once deployed.
    - Evaluations differ by type: trainees work directly on hard trainers, but cause wear and tear and incur possible injuries (as in real life); while soft trainers permit ready data collection but sacrifice the physical experience and manual task control. Software promotes computer-based testing for concept understanding and skill transference.
    - Possible research question: Software trainers can be of value when the problem demands some level of abstract reasoning and problem flexibility, but demand more time and effort cost for updates. What process can be used to evaluate whether a software training investment is effective and efficient from cost and learning perspectives?
- The *technology hardware* scene is rapidly evolving with new options in mobility and processing power.
    - For learners, technology should be easy to use, light weight, possibly portable and wireless, and multi-functional to avoid gadget proliferation. Devices must adequately support screen resolution and data storage requirements for anticipated schematics and diagrams, and must be visible and readable in the learning environment.
    - Instructors likely prefer inexpensive technology to mitigate device loss or damage, require flexible content use and update, and may want multi-modal capability for voice or hands-free operation. In addition, instructors may leverage opportunities for two-way communication for questions, assignment

submission, and collaborations. Such devices may also hold potential for multiple natural language support and/or translation.

    - Evaluating technology-based learning devices includes research questions such as determining appropriate information presentation density "per square inch" and studying the actual learning transfer relative to other media (paper, hard trainer, real system).

- *System architectures* must tale into account existing hardware and communication structures.
    - From a learner's perspective, "small" device capabilities are increasing; leading to "smarter" portable devices with wireless download, 3D graphics, video, and multi-modal interfaces. Local software and interactive systems minimize the need for constant connectivity (e.g. local server or the Internet), but connectivity is already ubiquitous, and nearly free for portable devices. Thus client-server systems offer good trade-offs for updating content and enabling collaboration.
    - Likewise, the instructor can access, control, and update server-side content, which must be pushed to learners' devices though extant wireless connectivity or even memory-stick transfer. The instructor can access and receive uploaded information from student devices for evaluation.
    - For learner evaluation, the line between Internet and local networks are blurred at the device level, meaning that content and individual assessments can be conducted through a server-side interface.
    - The research questions here involve (a) the need to determine the most likely wireless computing environment compatible with selected devices, course content and learning goals, and (b) how to best design and develop the software/communications/hardware architecture to support mobile learning.
- Given that the requirements for many learning tasks involve a visual component, *technology display properties* are highly relevant to the teaching process.
    - For the learner, classroom active whiteboards have not been very successful. Learners possess mobile phones, but no common platform is mandated. Laptops are expensive and less portable for field use. Augmented reality displays (wearable eyeglass mounted sliver displays) for content overlay are lightweight, attractive and relatively inexpensive for information presentation in context, but require a wearable computer or future portable device communications link (such as Bluetooth). Voice control, if reliable, would be useful for hands-off procedure stepping. Also, voice input/output may be difficult in noisy environments, so one may need to utilize some wired or wireless COM link.
    - Display technology is important to instructors, as it is the primary communication channel for visual instructional materials. While classrooms have projection equipment, they are not necessarily available in hangers or on the flightline. Portable display devices allow pushing content to the point of use, while augmented reality display systems can even move information into proximity (registration) with physical systems.
    - Evaluation techniques might test if task steps translate into proper, faster or better part location, positioning, removal, tool use, etc. by comparing results

with and without “on-site” visual aids (e.g. augmented reality to minimize errors).
    - Accordingly, some research questions include determining (a) what learning dimensions are best served by which display technology, (b) studying inexpensive augmented reality for training/jobsite Technical Order presentation and task views, location, and process visualization, and (c) what displays are best for hazard mitigation and training with respect to cautions and warnings?
- *Software design* and implementation are the major human capital expenses and bottlenecks in developing instructional systems.
    - From the learner’s perspective, canned demos are rigid, specific, and lack generalizability (limiting concept formation). Interactive Computer-Based Training (CBT) is an industry standard, being primarily workstation-based, self-paced, oriented toward specific outcomes, but usually lacking connection with physical systems that are the subject of maintenance instruction. Shared virtual environments such as Second Life and the proposed Air Force MyBase encourage exploration, but may become unstructured if not carefully designed. These systems encourage communication for information and problem-solving, and thus also open possibilities (and problems) for social networking and peer collaboration. Contemporary learners (Millennials) also seem to be motivated by games: interactive systems that capitalize on human characteristics to explore, experience, seek goals, obtain rewards, and challenge competitors through rapid response, strategic adaptation and a desire to “win.” Some “games” may utilize simulations in a standalone system or as an adjunct to a game or collaborative environment. These simulations provide more open-ended exploratory and learning experiences with varying possibly outcomes (with the possibility to learn from failures).
    - For instructors, canned demonstrations possess limited explanatory power. Interactive CBT, though an industry standard, appears not well integrated into the existing Air Force schoolhouse mindset and, moreover, is less suitable for physical training tasks. A virtual environment such as MyBase may encourage exploration, but must be carefully designed and aware that there are unknown consequences of social communication in these environments. Authoring games will likely require time and expertise beyond normal instructor skill and energy commitments and thus involve external (contractor) development support. Likewise, simulations whether part of a game or standalone, would most likely also require external development support.
    - Evaluating learning in computer-based systems is highly quantitative and includes a range of evaluation metrics from binary correctness to game timing/score to depth to experiences attempted.
    - Research questions include (a) what are the features that help determine a “best” computer implementation platform for a desired learning outcome, (b) what are existing data points that can help us understand the shape and slopes of student learning performance in this space, and (c) what would be the best software structure learning environment in which potential washbacks and

failures can be detected and mitigated though additional experiences, interventions, or social context?

- *Network technology* allows multiple users to share the same space, data, or experiences.
    - For the learner, networking opens doors to collaboration and teamwork rather than isolated individual action. Individual instruction, skill assessment and self-awareness are still important, but collaboration is important to the Air Force mission and involves teamwork, group problem-solving, and peer mentorship. The option of using social networking capabilities supported by Second Life or the proposed MyBase allows exploration of a large possibly unstructured space, but also opens the door to undesirable outcomes such as time wasted, time lost, missed opportunities, failure to achieve goals, etc. One option is to use virtual teammates, both to encourage collaboration and task focus, but also to allow team activities without the entire team being physically present. This opens up 24/7 task rehearsal and practice, removes the stigma of failure in a group, and increases understanding of the need for and communication with other members of the team.
    - For the instructor, one student at a time means maximum attention for that student, but possibly less efficiency in the classroom as a whole. A collaboration experience could be valuable if that experience produces the desired learning outcomes or satisfies specific training objectives, as it exposes language, communication and coordination issues up front during the learning phase. In this regard, the virtual Second Life approaches are currently unproven for learning *physical* skills or collaborative *physical* tasks. It is known, however, that virtual adversaries and teammates are of proven value in military operational simulations.
    - Evaluation would depend primarily in learning transfer to the physical individual or teamwork environment and situation. One could measure quality and content in communications before and after training experience.
    - Research questions must address the value of virtual team-members to training for multi-person skills (maintenance) as opposed to the planning and real-time execution of operations such as those in *America's Army*. Some positive outcomes are appearing from the interactions of learners with virtual collaborators or adversaries in projects at the Institute for Creative Technologies (ICT) at USC.
- Technology offers options for the *user's role* or engagement in the learning process.
    - The learner's role in *passive* (3rd person) activities include watching some activity with the possibility of changing or interrupting it. Early CBT systems used canned or branching video to allow decision points within a fixed prepared script. Many computer games fall into this category as well. By placing the learner in an *active* (1st person or *avatar*) experience, feelings of *presence* and *control* in the environment may be accentuated. These experiences allow the subjects a real life visual perspective, and enhances understanding of their physical relationship with the surroundings. When combined with simulations, the experience can be relatively flexible and

open-ended. The presence of some structured story line, guide, or coach is useful for managing the interaction and keeping the student on task.

  - From the instructor's perspective, the advantage of the active, first person approach is the direct connection to the experience: doing rather than just watching. The advantages to the passive 3rd person view are being able to perceive the whole body's relationship to space, structures and other people, and to visualize errors as those of someone else. Typical assessments should compare these two types of experiences.
  - Research questions include: (a) how can we develop test suites to assess and compare these two types of experiences and (b) can computer games be used to assess an individual's possible vocational skills by observing selection and performance across a representative sample of genres?

- Technology allows a variety of channels for *user inputs* to a learning system.
  - One can expect the Millennial learner to be relatively facile with standard mouse, cursor, joystick, and keyboard input devices. Voice is useful for hands-free operation, but difficult to justify in noisy operating environments, with speech or language variants, or with potential high understanding error rates. Motion capture has potential for teaching highly specific physical behaviors (such as surgery, possible Improvised Explosive Device (IED) disposal, etc.), but is relatively expensive to procure and awkward to manage. Very recent input device technology includes the Wii physical interface which is a cross between a game controller and two-hand motion capture. The Wii controller has some potential to teach primitive manipulative aspects of physical skill. Video (non-suited) motion capture is in the future (beyond 2010) but has the potential to collect physical performance data "non-invasively." Synthetic control panels or hard simulators, such as vehicle or airplane cockpit simulators, have seen limited application to maintenance or material handling tasks.
  - From the instructor's perspective, standard mouse, cursor, joystick and keyboard manipulation may be assumed in the learner's skill set, but text inputs are subject to varying language skills. Voice control appears awkward except for situations where the learner is already using a COM link and must communicate with team members or instructor. Motion capture would be outside the scope of typical instructor expertise and would slow down and even get in the way of the physical experience. Motion capture could be used, however, to develop "gold standard" actions by capable instructors to illustrate physical tasks since they allow 3D motion animations that can be examined from any vantage point, rather than the single point of view of a video. Video motion capture (for 3D data) is too technologically poor at this time to be considered an alternative to physical motion capture; moreover video capture requires more than one camera and a clear line of sight to the subject for each camera. A synthetic trainer for physical tasks would be equivalent to creating the "Holodeck": the real limitation is the inability of virtual scenes to impose large scale physical forces and torques on a subject – and even if they could, one must be wary of the concomitant danger of doing so!

    - Learner-side evaluations seem to require focus on skill transfer from familiar computer input tools to the necessity of physical experience. Tool skill acquisition in a virtual space must be tested on hard devices. Comparing a learner's physical performance to an instructor's "gold standard" via motion capture and comparative measurement can be reserved for certain critical tasks, but the software to do these comparisons must still be developed.
    - Research questions include (a) can motion capture and motion comparison be profitably used to train or even familiarize students with certain precision physical skills that may be required, (b) can the Wii controller be used for basic tool selection and appropriate use, and (c) can learner performance in games and simulations be used to help better predict career directions and skill affinities?
- Given the potential for a technological learning environment, an *instructor's role*, effort, and engagement may change.
    - Passive material preparation in advance for some form of visual or CBT delivery is the present norm. Active learning methods may require that the instructor be accessible via online system or through an avatar for outside class contact. The cost of this accessibility is usually prohibitive (as well as personally invasive), so there has been an emergence of systems for Guided Experiential Learning developed at ICT and under development at the University of Pennsylvania, for example. These systems offer virtual coaches, mentors, or aides that can guide or suggest behaviors, allow a safe environment in which to make errors, or step in to help redirect errors. The development costs of these systems are justified if military, health and social goals are important enough.
    - The evaluation of such instructor surrogate systems is not fully mature However, one can measure time for task, error rates, and analyze questions posed to the virtual instructor and subjectively judge the quality of the answers or guidance received (if any).
    - There are still open research questions on the use of virtual agents or instructors for training and learning. They can be invasive and annoying (e.g. the infamous Microsoft paperclip character). So one question to be addressed is how is a virtual instructor best utilized? What learning outcomes are affected (positively or negatively) by the existence of a virtual instructor? Can virtual instructors be extended to on-the-job training applications as well as schoolhouse use?
- Technology alone does not provide a learning environment; it must be supported by appropriate, in-depth, and carefully *authored content*.
    - Individual instructor authoring choices may be very limited, such as paper, text, PowerPoint, or Flash materials. Communities of instructors may develop materials on websites or wikis. In-house or external contractors may be needed for content authoring for some CBT systems involving computer programming. Contractor support will very likely be required for specialized games and simulation tools, as well as virtual environments such as MyBase.
    - For course evaluation, and authored content must correlate with curricular goals and instructor capabilities; any mismatch will hurt "programmatics" or

content delivery and hence learning success. Rather than a least common denominator approach, appropriate authoring tools must be utilized to achieve learning goals given the available or desired delivery technology.
    - Research questions here include (a) what Air Force institutions and instructor training materials need to be modified to achieve more agile content generation goals, (b) what role, if any, do instructors have as it pertains to content authoring in advanced learning environments, (c) if they do have a role, then how can future technological systems enhance content authoring at the instructor level, and (d) how can we measure instructor effectiveness in the transformation of learning and curricular goals into technology-based instructional materials?
- Once content is authored, it may not be permanent or static, *content changes* and evolves over time as systems are modified or upgraded, procedures are refined, etc.
    - This presents issues for instructors, as they may have no access or ability to change the stored content. Systems that use databases or wikis may be more flexible. Software systems built by external contractors may be fixed or brittle to change and may present expensive upgrade or correction costs.
    - The potential need for content updates should be part of the evaluation process for technologically-based learning systems. Review processes are needed to ensure content consistency and accuracy, to organize and maintain responses to frequently asked questions, to develop novel group exercises, or to exploit existing and emerging technological features.
    - A desirable research goal, therefore, is to ensure that technology-based authoring tools are accessible and content-updateable by instructors. Are there authoring systems being overlooked or other options on the technological horizon? Can quantifiable benefits from guided experiential learning be transitioned to lower cost, maintainable, extensible systems?

Whatever technological approaches to learning are investigated, we must always be cognizant of the *safety, policy, social and regulatory issues* associated with any technology adoption or use. It is also important that decisions regarding the adaptation or development of technologies for applications in training consider the return on investment not only from a cost perspective (including reduced training time), but also with consideration for helping better achieve or enhance desired learning outcomes.

3.4 Future Training/Learner Pilot Study

In addition to the workshops and other research activities discussed above, a small pilot study was undertaken at the 82nd TRW, Sheppard AFB, TX to better understand the learning preferences of Air Force Technical Training trainees so as to recommend modifications and redesign of technical training to improve engagement, comprehension, and successful course completion. The details and results of this study are described more fully in the report titled *"21st Century Training for 21st Century Learners"* included as Appendix D to this final report. A summary of the pilot study goals, study approach, and results are summarized in this section.

The goals of the pilot study were informed, in part, by the data collection and workshop activities conducted as part of the DO-9 research effort. These goals included the following: a) determining whether current Air Force Technical Trainees' are 21st century learners - based on

attributes and characteristics discovered through our literature search; b) assessing whether Air Force technical training is aligned with trainees' learning preferences and identifying areas of potential improvement; and c) identifying leverage points in training where innovations in technology could potentially improve training outcomes. To accomplish these goals, a review of literature was conducted, a Technical Training Observation Rubric (TTOR) was developed for use in technical training classroom observations of teaching methods, and responses to "preference" inventories (based on the Grasha-Reichman learning and teaching style inventories) were collected from trainees and instructors respectively.

The Learning Styles Inventory (LSI) was administered to 172 trainees at Sheppard AFB representing six different technical training courses. Responses on the LSI supported the generalization that AF technical trainees are 21st century learners with a mean LSI composite of Participant/Dependent/Collaborative. The Teaching Styles Inventory (TSI) was administered to 22 technical training instructors in six courses. Instructor responses indicated they preferred Teaching Style Cluster 2- Personal Model/Expert/Formal Authority (see attached report) with secondary preferences for the Facilitator/Delegator styles. Grasha's research suggests that Teaching Styles Cluster 2 best supports students with the Participant/Dependent/Collaborative learning styles composite.

The LSI-TSI data indicated there was alignment between instructors' preferred teaching cluster and trainees' learning preferences. However, responses on the technology use items (added to the LSI and TSI for this pilot study) indicated that trainees preferred more technology use in instruction than did their instructors. In addition, while the LSI and TSI data indicated alignment between instructors' and trainees' preferences, classroom observation ratings using the TTOR indicated instructors were not observed teaching in their preferred Teaching Styles Cluster. Observed instruction was not representative of 21st century methods.

The findings of this pilot study suggested that technical training instruction could be better aligned to meet both instructors' preferred teaching styles and trainees' learning preferences, and these findings are discussed in more detail in attached pilot study report. One point worth citing here is that the study did indicate that there is some alignment between instructors' and trainees' preferences – which is good news, in that it suggests that instructors possess the desire and inclination to teach in ways that support 21st century learners' preferences for participation, self-direction, competence and collaboration. However, observed instruction did not utilize recommended 21st century practices such as: cooperative learning, role modeling, illustrations, problem-solving, multiple examples, discussions of alternative approaches, sharing of thought processes for obtaining answers, sharing of personal experiences, coaching and guiding with feedback, or visual tools.

4.0 CONCLUSIONS AND RECOMMENDATIONS

This research effort provided an excellent opportunity for developing a better understanding of the current and future challenges confronting the Air Force technical training environment. While the scope of the research and data collection focused primarily on technical training activities at the 82nd TRW at Sheppard AFB, TX, the technical training challenges cited in this report are arguably common to the challenges faced by other Air Force locations conducting technical training (e.g. Keesler AFB, Lackland AFB, etc.). Therefore, the research questions and topics discussed in this report are intended to be applicable to (or have some implications for) the Air Force technical training community as a whole. As stated earlier, it is

important to recognize some of the training challenges and needs addressed in this report are significantly impacted by factors that will most likely not be resolved or addressed through research alone. Budgetary constraints (e.g. replacing or upgrading training equipment, trainers), current operational tempo (e.g. pressure to increase throughput of students to support on-going operations), and current organizational and training policies and procedures, are factors that also need to be considered as part of formulating a future research agenda for technical training.

The report proposes six vectors of research for technical training and potential research questions and topics for each vector that are deemed important to the development of a research agenda for technical training. These vectors include: Learners, Methodology, Instructor, Environment, Evaluation, and Technology. While the research questions and topics raised for each vector are considered important in the development of a research agenda for technical training, the vectors cited in this report are not totally independent. There is interdependence between some vectors in terms of the questions and topics raised that should be considered in the development of a research agenda. For instance, the evaluation of training technologies supporting the development of training for deployment in advanced learning environments such as proposed by the MyBase vision will require suitable metrics for evaluating there impact on learning outcomes, cost effectiveness, and current instructional systems design and development processes. These type metrics and criteria currently do not exist for effectively evaluating learning outcomes (and cost effectiveness) in advanced learning environments such as those utilizing virtual reality and incorporating the use of avatars. Hence, to effectively evaluate technologies for specific technical training applications in these environments, a research agenda might first start with identifying relevant metrics and methods for collecting data and measuring learning outcomes against these metrics. The next step might be to conduct research using these metrics in specific training contexts utilizing advanced training technologies to assess the impact on learning outcomes, degree of accommodation for different learning styles, as well as to inform the refinement of metrics, and impact on current curriculum development processes (e.g. ISD process), instructor training, etc.

Another point worth noting is that not all the questions and topics involve long-term research efforts. For example, the pilot study accomplished as part of this report indicated that while there appears to be alignment between the learning styles of trainees (21^{st} century learners), and the preferred teaching styles of instructors (i.e. to teach in ways that support 21^{st} century learner preferences), 21^{st} century teaching practices, utilizing methods such as cooperative learning, role modeling, etc. were not consistently observed in the courses included in our pilot study. Traditional teaching methods utilizing lecture, PowerPoint presentations, etc. were the primary methods observed (about 75 percent of the time). Hence, near term research might focus on better understanding the reasons for this misalignment or contradiction to possibly inform changes (using current “best” practices) to the structure of curriculum, instructor training, etc. that might be currently constraining instructors in the classroom.

The technical training environment offers a rich opportunity for future research as demonstrated by the challenges cited in this report and the questions and topics formulated under each of the six research vectors. Since numerous technical training courses, such as those observed as part of this research effort, require hands-on involvement (using real equipment or trainers) at some point by trainees for performance-based training evaluation, it will be important to ensure that long term research to enhance technical training is focused on finding the right balance or mix (in terms of costs, reduction in training time, and learning outcomes) between the use of advanced training technologies and methods for training, and traditional, yet highly

effective, hands-on training methods. This is probably one of the most significant considerations for future research in technical training.

REFERENCES

[1] Karoly, L. & Panis C. (2004). *The 21st century at work: Forces shaping the future workforce and workplace in the United States* (MG-164). Santa Monica, CA: RAND Corporation, (http://www.rand.org/pubs/monographs/MG164/index.html).

[2] Karoly, L.A. (2007). *Forces shaping the future U.S. workforce and workplace: Implications for 21st century work*. Congressional Testimony presented before the House Education and Labor Committee, Washington, DC (CT-273). Santa Monica, CA: RAND Corporation.

[3] Toosi, M. (2002). A century of change: The U.S. labor force, 1950-2050. *Monthly Labor Review*, 5: 15-28.

[4] Toosi, M. (2006). A new look at long-term labor force projections to 2050. Monthly Labor Review, 11: 19-39.

[5] Ware, J., Craft, R., & Kerschenbaum, S. (2007). Training tomorrow's workforce. *Training and Development*, 61(4): 58-60.

[6] Bergman, S.M., Medway, R.L., Turner, S.R., Marsh, S.M., Zucker, A.B., & Boehmer, M. (2007). *Department of Defense youth poll wave 13: Overview report* (JAMRS Report No. 2007-001). Arlington, VA: Joint Advertising, Market Research and Studies.

[7] Oblinger, D. (2003). Boomers, Gen-Xers and Millennials: Understanding the new students. *EDUCAUSE Review*, 38(4): 36-45.

[8] Rodgers, M., Runyon, D., Starrett, D., & Von Holzen, R. (2006). Teaching the 21st century learner. In *Proceedings of the 22nd Annual Conference on Distance Teaching and Learning*. Madison, WI: University of Wisconsin System.

[9] Oblinger, D. (2004). Educating the net generation. *EDUCAUSE 2004* (Keynote Speaker), October 19-22, Denver, CO.

[10] Air Education and Training Command (2008). *On learning: The future of Air Force education and training* (White Paper). Randolph Air Force Base: TX: Air Education and Training Command.

[11] Blascovich, J.J. & Hartel, C.R. (2008). *Human behavior in military contexts*. Washington, DC: National Academies Press.

[12] Graesser, A.C. & King, B. (2008). Technology-based training. In J.J. Blascovich & C.R. Hartel (Eds.), *Human behavior in military contexts* (pp. 127-149). Washington, DC: National Academies Press.

[13] Guskey, T.R. (2002). Does it make a difference? Evaluating professional development. *Educational Leadership*, 59(6): 45-51.

[14] Hiemstra, R. (2006). Aspects of effective learning environments. *New Directions for Adult and Continuing Education*, 1991(50): 5-12.

APPENDIX A - Workshop # 1 Agenda

Anticipating Future Job-Aiding / Training Requirements, TACS DO-9
Workshop #1 Agenda
30-31 January 2008
Sheppard AFB, TX

Sheppard AFB Billeting Office, Conference Room #2 (Upstairs)

30 January 2008 (Wednesday)

Time	**Session**	**POC/Format**
0730-0800	Continental Breakfast (Conference Room)	Ms. Gina Johnson Mr. Pat Vincent
0800-0815	Welcome / Introductions / Admin Remarks	Mr. Alex Nelson Ms. Gina Johnson
0815-0830	Keynote Address (Col Marti Rossi, 82 TRW/DS) Director, Wing Staff	Ms. Gina Johnson 82TRW/TOO
0830-0900	82 TRW Mission Overview and Training Technology function (TOO-T) Overview	Presentation: Ms. Gina Johnson, 82TRW/TOO
0900-0945	TACS DO-9 Overview and Discussion • Task Scope and Technical Objectives • Technical Approach • Accomplishments to Date • Operational/Training Environment (Challenges) • Workshop Objectives	Presentation (20-25 min): Mr. Pat Vincent Northrop Grumman Corp. Ms. Jill Ritter AFRL/RHAL Discussion (35-40 min)
0945-1000	Break	
1000-1045	Future of AETC/Air Force Education and Training Objective: Provide a general overview of the future direction of AETC/AF training. Mr. Clemons to leave for airport at 1045.	Presentation (15-20 min): Mr. Larry Clemons HQ AETC/A5TT Discussion (25-30 min)
1045-1100	Short Presentations by Dr. Lindsey/Dr. Badler	(5-10 min each)
1100-1215	Lunch at Sheppard AFB Officer's Club This will be a cafeteria style lunch and Gina will plan to invite a few other personnel from the 82 TRW	Ms. Gina Johnson
1215-1315	Training / Field Evaluation Process and Feedback	Presentation (15-20 min): 82 TRW Training Evaluation, Mr. Gerald

Time	Session	POC/Format
	Objective: Provide an overview of the training evaluation process, types and purpose of surveys / questionnaires used for evaluation. Discuss common themes across training courses that point to current training challenges / shortfalls. How do career fields compare in this regard? Are some courses more problematic in terms of washback rates, ability to train certain skills, etc.	Carr Discussion (40-45 min): to include Mr. Carr and a representative from each of the four Group Training Evaluation functions: Gary Stevenson, MSgt Perez, Mike Mauldwin, Bobbie Merrifield
1315-1430	General Overview of the Instructional Systems Development (ISD) Process Objective: Provide a general overview of the ISD process with an emphasis on training system design and development. Discussion on how well does the current ISD process accommodate future training or learning environments? What are the challenges ahead for designing and developing training systems for future AF learners?	Presentation (15-20 min): 82 TRW Faculty Development, Presented by: Cheryl Whelan, Faculty Development, Training Development Chief Attended by: Barbara Light, Don Williams, and Beth Yates, Course Single Point Managers Discussion (40-45 min) Group Discussion
1430-1445	Break	
1445-1545	Structured Interview with Instructors Interviews to gain insight into current training challenges, shortfalls, and perspectives on alternative approaches to designing and delivering training.	AFRL Research Team, Ms. Gina Johnson, Mr. Steve Brite, and 3-5 82 TRW Instructor Personnel representing different courses
1545-1630	Discussion of Training Challenges / Shortfalls The intent of this session would be to begin to develop some common ground / understanding (based on the material and information presented earlier in the day, as well as interviews) on some of the key challenges and shortfalls related to training future warfighters	Working Group Discussion AFRL Research Team, Ms. Gina Johnson, and Mr. Steve Brite
1630-1645	Hot Wash Recap highlights and review actions from the day, and review agenda items for next day	Mr. Pat Vincent

31 January 2008 (Thursday)

Time	**Session**	**POC/OPR**
0700-0730	Coffee and Donuts (Conference Room)	Ms. Gina Johnson
0730	Board bus and travel to view first training event	Ms. Gina Johnson
0730-0930	Observe Training Events • Block 7, Electro-Environmental Course (high washback rate / difficult to train) • Fuels Systems Course (technology insertion / use of equipment in classroom) • Additional Event - TBD	Ms. Gina Johnson
0930-1030	Instructional Technology Units (2), and Trainer Development Round table in Conference Room	Ms. Gina Johnson
1030-1130	Visit with BG Devereaux, 82 TRW/CC	Ms. Gina Johnson
1130-1230	Lunch - Golf Course	Ms. Gina Johnson
1230	Workshop General Session Ends	

APPENDIX B - Instructor Interview Session Questions

Anticipating Future Job-Aiding / Training Requirements Workshop #1

1. What course(s) do you currently instruct?

2. How long have you been an Instructor/Instructor Supervisor?

3. What are the most significant training challenges you are up against in providing training to your students? How are you attempting to address these challenges?

4. Based on course/block objectives and student feedback/performance, how effective do you feel the current methods are for training students that are coming through your courses?

5. What training methods (in ref. to the mode of instruction) do you think work best? Which training methods do you feel are less successful? Why?

6. What do you think the students you train like and dislike most about their training?

7. Do you notice a trend in how your students tend to learn or perform?

APPENDIX C - Summary of 82nd CoP Responses to Instructor Interview Session Questions

Responses to Questions #1 and #2 pertained to the specific course an instructor was assigned and their years of experience. This data is not included in the report.

Question #3 - What are the most significant training challenges you are up against in providing training to your students? How are you attempting to address these challenges?

- Shortage of Instructor personnel (manning)
- Instructor workload is significant – course related and additional duties
- Outdated and broken training equipment / trainers / tools
- Aircraft – age and availability
- Lack of funding to purchase equipment / tools / computers
- Technology
- Keeping pace with new technologies and insertion into training
- Lag time in incorporating technology due to funding / resource constraints
- Keeping students "engaged" in course material / training
- Motivation of students to learn / self-discipline

Question 4 - Based on course/block objectives and student feedback / performance, how effective do you feel the current methods are for training students that are coming through your courses?

- General consensus was that current methods for training students were "good" / "effective"
- A few indicated that some course material was outdated / not relevant
- Some indicated a need to introduce more technology (beyond Powerpoint presentations) – primarily to engage students and reinforce material

Question 5 - What training methods (in ref. to the mode of instruction) do you think work best? Which training methods do you feel are less successful? Why?

- Hands-on training is best (maintenance courses in particular)
- Lecture and PowerPoint presentations are not that effective or interesting to the students
- Modeling and simulation for demonstration or practice would help reinforce some concepts and reduce wear and tear on trainers / equipment

Question 6 - What do you think the students you train like (+) and dislike (-) most about their training?

- + Hands-on / interactive training and demonstrations
- - Lecture / Powerpoint presentations and "knowledge" objectives
- - Military training activities and additional duties outside the classroom
- - Time it takes in training to get their hands on the actual aircraft or equipment
- - Fast pace of instruction in some courses
- - Downtime during training (particularly during class time because of lack of equipment, instructors, etc.)
- - Limited or no access to course training materials outside of class for study purposes

Question 7 - Do you notice a trend in how your students tend to learn or perform?

- Majority indicated that they did seem to notice a trend in how their students learned / performed – only some qualified their responses
- About 15 percent indicated they did not notice a trend
- Some of the comments pertaining to trends included:
    - Younger students seem to respond better interactive technology and computer based applications
    - Students seem to learn quicker when they can move from the classroom to the hands-on environment
    - Some students seem more lethargic because of the length of day that includes course time and military training / additional duties
    - Some students have a problem with time management

APPENDIX D - 21st Century Training for 21st Century Learners - A Pilot Research Study

Jill L. Lindsey, Ph.D.

Dayton, Ohio

December 2008

Accomplished as part of the research conducted for TACS DO-9

Funded by AFRL/RHAL

Executive Summary

A pilot research project was undertaken to better understand the learning preferences of Air Force technical trainees so as to recommend modifications and redesign of technical training to improve engagement, comprehension, and successful course completion. The goals of the study were:

1. Determine whether current Air Force technical trainees' are 21st century learners.
2. Assess whether Air Force technical training is aligned with trainees' learning preferences and identify areas of potential improvement.
3. Identify leverage points in training where innovations in technology could potentially improve training outcomes.

To accomplish these goals, a review of literature was conducted, an observation rubric was developed for use in technical training classroom observations, and responses on preference inventories were collected from trainees and instructors.

The review of literature revealed a growing consensus regarding the attributes and preferences of 21st century learners and recommended instructional practices to best meet their needs. The literature suggested that 21st century learners:

a. desire meaningful work
b. are self-directed in setting and achieving goals
c. prefer working collaboratively
d. have a sense of capability or competence
e. have strong visual-spatial skills
f. tend toward parallel processing (multi-tasking)
g. are technologically intuitive

The recommended instructional methods:

a. provide opportunities for collaboration using Cooperative Learning
b. harness learners' technology authority and innovation
c. recognize their visual-spatial skills and ability to parallel process
d. require them to take responsibility for their own learning by providing opportunities for choices, decision-making, and selecting learning strategies
e. give learners autonomy while establishing high expectations and encouraging metacognition
f. support learners' sense of competence with frequent praise and feedback
g. assign meaningful work

The Grasha-Reichmann Learning Styles Inventory (LSI) and Teaching Styles Inventory (TSI) were selected to identify the learning preferences of trainees and the teaching preferences of instructors. Grasha's research identified four common clusters of teaching styles and associated student learning styles for the most effective teaching-learning dynamic. Each of the Teaching Styles Clusters and learning styles composites are made up of two or three primary styles with one or more secondary styles. The learning and teaching styles identified by the LSI and TSI correlated but did not directly align with the 21st century preferences and methods identified in the literature, and no items addressed technology use. Therefore, ten additional items related to

technology use were added to the LSI and TSI. Selected items from the LSI were also mapped to six 21st century learning preferences to enable the computation of 21st century learning preference scores. To measure the degree of alignment between 21st century learning recommendations and Air Force technical training methods, a 21st Century Technical Training Observation Rubric (TTOR) was developed. The rubric identified nine criteria with three or more examples of possible evidence. The first eight criteria described 21st century instruction and the ninth criteria documented traditional instructional methods.

The TTOR was used to document classroom observations of seventeen instructors in six courses. The observation protocol involved teams observing each class for 20-30 minutes with note-taking, followed by assigning ratings based on the evidence noted. Observers individually completed their ratings for each TTOR criteria (0= not observed, 1= seldom observed, 2= observed about half of the time, 3= observed most or all of the time). Following each observation period, the observers gathered to discuss their evidence and individual ratings for each class/instructor. Most observations resulted in common ratings by the observers but when differences in individual ratings occurred, discussion of evidence resulted in a consensus rating. Observed instruction was dominantly traditional using lectures with slides, but a few classes included active student participation in 21st century methods.

The Learning Styles Inventory (LSI) was administered to 172 trainees. Responses on the LSI supported the generalization that AF technical trainees are 21st century learners with a mean LSI composite of Participant/Dependent/Collaborative. The Teaching Styles Inventory (TSI) was administered to 22 technical training instructors in six courses. Instructor responses indicated they preferred Teaching Style Cluster 2- Personal Model/Expert/Formal Authority with secondary preferences for the Facilitator/Delegator styles. Grasha's research suggests that Teaching Styles Cluster 2 best supports students with the Participant/Dependent/Collaborative learning styles composite.

The LSI-TSI data indicated there was alignment between instructors' preferred teaching cluster and trainees' learning preferences. However, responses on the technology use items indicated that trainees preferred more technology use in instruction than did their instructors. In addition, while the LSI and TSI data indicated alignment between instructors' and trainees' preferences, classroom observation ratings using the TTOR indicated instructors were not observed teaching in their preferred Teaching Styles Cluster. Observed instruction was not representative of 21st century methods.

The findings of this pilot study suggested that technical training instruction could be better aligned to meet both instructors' preferred teaching styles and trainees' learning preferences. Adjustments in teaching to include more 21st century methods would accommodate both instructors' and trainees' preferences. Trainees expressed the desire for more technology use in the classroom and for digital access to course materials. Even though instructors' responses on technology items were slightly lower than those of trainees, instructors' ratings indicated they would like to incorporate more technology into the training process. A variety of technologies beyond the common power-point lecture are available to incorporate into the learning environment. Online wikis and blogs can also help build collaboration and communications skills, while social networks provide access to expensive or scarce high-level tools. When guided by training objectives, small-scale shifts in technology use can offer trainees meaningful learning experiences and increased interactivity. This is an area where technology innovations could

improve engagement and learning outcomes. Further research is needed to determine the impact of electronic course materials and digital communications in technical training.

The alignment between instructors' and trainees' preferences is good news, in that it suggests that instructors possess the desire and inclination to teach in ways that support 21^{st} century learners' preferences for participation, self-direction, competence and collaboration. However, observed instruction did not utilize recommended 21^{st} century practices such as: cooperative learning, role modeling, illustrations, problem-solving, multiple examples, discussions of alternative approaches, sharing of thought processes for obtaining answers, sharing of personal experiences, coaching and guiding with feedback, or visual tools. Since instructors preferred but were not observed enacting 21^{st} century teaching methods in the classroom, there is need for further exploration of this contradiction. Perhaps aspects of the training environment or the structure of the curriculum are constraining instructors from teaching in their preferred styles. Perhaps Instructor Training should be redesigned to prepare instructors to use 21^{st} century best practices. These are a few of the many avenues for future research revealed by this study. The evidence from this pilot study revealed that Air Force technical trainees are 21^{st} century learners and improving technical training instruction through the use of 21^{st} century practices merits further investigation.

Introduction

There is an ever present need to improve technical training so as to efficiently produce qualified airmen while reducing the time and costs associated with preparing them for field-ready status. Innovative technology can play a role in such improvements, but only to the extent that the technology actually improves training practices and meets learners' needs. Before making investments in technology, the Air Force must examine the technical training environment in the context of today's learners in order to identify those places where innovation will offer the greatest impact. At the most fundamental level, the trainee's experience and needs as a learner must be considered. A recent report on *Human Behavior in Military Contexts* (Blascovich & Hartel, 2008) concluded that "first and foremost training programs should be based on an understanding of how people learn and how instructional methods affect learning."

The learners in the 21st century are different in many ways from their instructors. There is a growing body of literature describing the 21st century learner as interactive, collaborative, experimental, multi-tasking, visual and kinesthetic (Oblinger & Oblinger, 2005). A better understanding of the learning needs of 21st century trainees can guide the modification and redesign of technical training instruction, methods, policies, and practices to improve student engagement, comprehension, and successful course completion. It can also provide decision makers evidence-based recommendations for selecting technologies with the highest potential to improve learning outcomes and graduation rates. To this end, a pilot research project was undertaken with the following goals:

- To better understand current technical training challenges related to trainees' attributes and learning preferences
- To examine alignment of teaching and learning modalities in current technical training and identify areas for improvement
- To identify leverage points in training where innovations in technology could improve training outcomes

The project unfolded in four phases:

1. A review of literature exploring the evolving consensus among researchers regarding 21st century learners' attributes and preferences (predispositions, skills, and preferred learning modalities), and identified "best practices" in training and education to meet the needs of 21st century learners.

2. Data Gathering Tools.

a. The development of a 21st Century Technical Training Observation Rubric for use in assessing the degree of alignment between recommended 21st century training practices and current technical training practices.

b. The selection of the Grasha-Reichmann Learning Styles Inventory (LSI) to administer to a sample of trainees to determine if their learning preferences match preferences described in the literature about 21st century learners.

c. The selection of the Grasha-Reichmann Teaching Styles Inventory (TSI) to administer to technical training instructors to identify their teaching styles preferences.

3. Data Collection and Analysis.

a. Conducted observations (n=17) in six technical training courses using the 21st century Technical Training Observation Rubric.

b. Collected Learning Styles Inventory responses from a sample of technical trainees.

c. Collected Teaching Styles Inventory responses from a sample of technical training instructors.

4. Discussion of the findings and recommendations related to improving technical training.

This paper describes the activities and insights gained in each of these phases.

1. Review of Literature

A review of literature was undertaken to explore articles, texts and research studies related to 21st century learners' attributes and to identify instructional practices designed to best meet the needs of 21st century learners. The umbrella of learner attributes explored included predispositions, types of knowledge, identified strengths and skills, and preferred learning modalities. The review of literature revealed a growing consensus regarding the attributes and preferences of 21st century learners and recommended instructional practices to best meet their needs.

Who are 21st Century learners? Twenty-first century learners are considered "Millennials" born in or after 1980, and make up nearly 30 percent of the American population. They are the most racially and ethnically diverse generation to have come along in American history. A variety of labels have been applied to the sub-groups within the Millennial umbrella, the most common are Generations Y and Z. Those who subscribe to the alphabetical subdivisions separate the groups by birth years: members of Generation Y were born between 1980-1994 and Generation Z between 1995-2009. Those who distinguish between these two groups do so because Generation Z is the world's first generation to be considered digital "natives," where Generation Y grew up during the development period of computer technologies and the Internet. There are many popular labels for 21st century learners: dot com kids, the Net Generation, Generation Media, and Generation C (with the "C" meaning click, connected, community, and/or creative).

21st century learners or Millennials, like other generations, are shaped by the events, developments, and trends of their time (Howe & Strauss, 1991). According to generational research (Howe & Strauss, 1991), many parallels exist between Millennials and the World War II generation. Both groups experienced the building of new schools, curriculum focused on math and science, standardized testing, character education in schools, school uniforms, youth volunteerism, government protections, and the popularity of the *Superman* archetype. They also hold similar values: teamwork, a sense of capability or competence, community before self, and respect for parents. These values appear to contribute to and support the decision to volunteer for community and military service.

Beyond these parallels, there are vast differences that make Millennials a unique generation. Millennials are viewed as the connected generation because they have had lifelong use of communications, the Internet, and media technologies. In America and Europe, they have also grown up in a world with widespread equality of the sexes and single-parent or same-sex parent families. Distinguishing differences between Generation Y and Z are their family contexts and political climates. Generation Y was the "two-income, daycare" generation while Generation Z is

the first generation after the Baby Boomers to be raised at home by parents and a single income family. Generation Y grew up in a post-Cold War environment, but Generation Z's landscape is dominated by the after effects of 9/11.

What are the key attributes and strengths of the 21st century learner? A growing body of literature suggests that 21st century learners can be described using a constellation of key attributes and preferences (McGlynn, 2005, 2008; Montana & Petit, 2008; Vander Schee, 2008; Abram, 2007; Moore, 2007; Dordai & Rozzo, 2006; Martin & Tulgan, 2006; Skiba & Barton, 2006; Johnson & Romanello, 2005; Oblinger, 2003; Raines, 2003: Ben-Jacob, Levin & Ben-Jacob, 2000; Howe & Straus, 2000). They: a) desire meaningful work, b) are self-directed in setting and achieving goals, c) prefer working collaboratively, d) have a sense of capability or competence, e) have strong visual-spatial skills, f) tend toward parallel processing (multi-tasking), and g) are technologically intuitive. While authors used a variety of labels and descriptors for 21st century learners, these key preferences emerged as common inter-related themes.

Most authors' descriptions focused on the interactive nature of 21st century learners, linking the desire for social interaction and collaboration with the use of technology. This common cluster of attributes indicates 21st century learners are digitally literate, mobile, experiential, social, and crave interactivity and immediacy (Skiba & Barton, 2006; Oblinger, 2003). They prefer to learn by working collaboratively and through teamwork (Koster & Smith, 2007; Rodgers, Runyon, Starrett, & VonHolzen, 2006; Skiba & Barton, 2006; Johnson & Romanello, 2005; Oblinger, 2003). Millennials are fluent in the digital language of computers, video games, and the internet (Prensky, 2001). Having been socialized in a digital world, they are more technically literate and connected to digitally streaming information than previous generations (Eisner, 2005). Some posit the increased need for socialization is actually a by-product of intense exposure to a wide array of communication technologies (Oblinger, 2003). Millennials not only use technology heavily, but also trust it implicitly (Hartman, Moskal, & Dziuban, 2005). This mobile generation uses PDA's, cell phones, MP3 players, and lap-tops to stay connected throughout the day. Utilizing different technologies, the Millennial is able to set up a connected world without having to stay in a fixed location. Millennials are comfortable with and enjoy using technology (McGlynn, 2005) and prefer to use it whenever possible (Abram, 2007). Often it seems as though the ability to use a variety of technological devices is almost intuitive (Oblinger & Oblinger, 2005).

A survey of 275,000 high school students identified volunteerism, collaboration and technology use as common behaviors and preferences (Oblinger, 2003).

- 74 percent volunteered in the last year/ 65 percent in the last month
- 94 percent used the Internet for school work
- 78 percent indicated the Internet helped them with their school work
- 81 percent used E-mail to talk with friends
- 56 percent preferred E-mail to the telephone
- 56 percent said the Internet improved relationships with teachers
- 89 percent received some information from their teachers via the Internet
- 19 percent would rather use E-mail than have a face to face interaction with a teacher

While instant communication technologies may explain the proclivity for peer interactions and immediacy, a related attribute is parallel processing. 21st century learners like to parallel process or multi-task, shifting their attention rapidly from one activity to another, and may choose not to pay attention to things that don't hold their interest (Oblinger & Oblinger, 2005). Parallel processing is a way of life for the Millennial, but some (Abram, 2007) worry that the multitasking lifestyle of Millennials contributes to a lack of focus and poor concentration skills. Rodgers, Runyan, Starrett, & Van Holsen (2006) found Millennials are good at reading visual images but weak in reading skills, have strong visual-spatial skills, tend toward parallel processing and inductive discovery, and have fast response time which tends to equal shorter attention spans. Increases in parallel processing may contribute to shorter attention spans, but Millennials appear quite comfortable when engaged in multiple activities simultaneously (Oblinger, 2003). Through a variety of technologies, Millennials are able to incorporate multitasking into day-to-day activities and satisfy their high need for interconnectivity (Hartman, Moskal, & Dziuban, 2005).

Another cluster of related attributes in the literature were competence, self-direction, and meaningful work. In a consumer trend research report for Iconoculture, Koster & Smith (2007) described four major characteristics of Millennials: collaboration, authenticity, flexibility, and reciprocity. These later three attributes work together to create a sense of competence in the 21st century learner.

> They're natural team players with an innate sense of entitlement that tells them that the entry-level sales rep deserves to have just as much input as the senior manager... They prefer flexibility, freedom, independence, and control…Life is a transaction…"you get what you give" is the golden rule… Reciprocity is very important when you are raised to believe that you always have a choice and you can always expect someone to want to hear your point of view. Connecting with this demographic means accommodating their need to be heard and be counted.

The need for recognition is integral to their sense of competence, in that Millennials rely on feedback and recognition to support and nurture feelings of competence. A recent study (Montana & Petit, 2008) explored the motivators for Generations X and Y and found the strongest motivators for both groups were recognition, followed by high income or good pay, good work relations, career growth opportunities, and the chance to do interesting/meaningful work.

This generation is very self-reliant and feels a need to achieve (Eisner, 2005). This need to achieve often harmonizes with the Millennials demand for meaningful work. The Center for Information Research on Civic Learning & Engagement (2007) has recently published research on the many ways Millennials are more actively involved in their communities. The study compared Millennials with Boomers and found Millennials have a great deal more experience with volunteering and believe in their obligation to work together with others on important social issues. This need for meaningful work is not limited to volunteering and social action. In a Northwestern Mutual (2004) study of desirable job traits, nearly half of all respondents ranked "doing work which gives me the opportunity to help others" as very important. Assigning

meaningful work and demonstrating the relevance of information are essential components in engaging 21st century learners (McGlynn, 2008).

Meaningful work is related to competence and self-direction, in that Millennials need superiors and peers to support them and nurture their growing competence with immediate, constructive feedback (Martin & Tulgan, 2006; Johnson & Romanello, 2005; Wagner, 2005). Self-direction is the third key attribute in this cluster. 21st century learners are independent, entrepreneurial thinkers, who love freedom and flexibility, and like having a sense of choice (Martin & Tulgan, 2006). When working on projects, the Millennial is likely to explore multiple options before deciding on a set path or focus (Abram, 2007).

This review of literature converged around several key attributes of 21st century learners: meaningful work, self-direction, competence, collaboration, technology use, and parallel processing. Once identified, these attributes were used to help guide the review of literature identifying best instructional practices for 21st century learners.

What are best practices for teaching and training 21st century learners? Millennials are highly collaborative and self-directed but in need of feedback and support to nurture their sense of competence. They learn in a variety of ways while parallel processing, are motivated and engaged by meaningful work, and are technologically literate. There exist a variety of suggestions for how to optimize these attributes and preferences. The most frequently recommended instructional methods align with the attributes and strengths of 21st century learners:

a. provide opportunities for collaboration using Cooperative Learning
b. harness learners' technology authority and innovation
c. recognize their visual-spatial skills and ability to parallel process
d. require them to take responsibility for their own learning by providing opportunities for choices, decision-making, and selecting learning strategies
e. give learners autonomy while establishing high expectations and encouraging metacognition
f. support learners' sense of competence with frequent praise and feedback
g. assign meaningful work

Learning experiences that encourage collaboration optimize 21st century learners' social and interactivity needs. Millennials enjoy working in groups and collaboratively constructing knowledge within a social community (Skiba & Barton, 2006). Cooperative Learning is a well-researched teaching method with results that demonstrate students learn faster and more efficiently, have greater retention, and feel more positive about their learning experiences. A Johnson, Johnson & Stanne (2000) meta-analysis of 164 studies investigating eight different types of cooperative learning methods found all eight cooperative learning methods had a greater impact on student achievement when compared with individualistic and competitive learning methods. Methods of Cooperative Learning create relationships between group members based on "positive interdependence (a sense of sink or swim together), individual accountability (each member has to contribute and learn), interpersonal skills (communication, trust, leadership, decision making, and conflict resolution), face-to-face interaction, and reflecting on how well the team is functioning and how to function even better" (Johnson & Johnson, 1997). Thus

cooperative learning methods not only address 21st century learners' preference for collaboration, but also address their needs for self-direction, metacognition, and competence.

Millennials have set themselves apart from previous generations in their desire to actively construct knowledge through interaction (Skiba & Barton, 2006; Oblinger & Oblinger, 2005). This emphasis on social learning is in sharp contrast to the traditional view that knowledge is passed down from expert to novice, teacher to student. This does not mean that the traditional classroom lecture has to be abandoned. Interactive lectures can encourage collaborative meaning-making by pairing short lectures with simulations, group activities, interactive exercises, and game-style review sessions (McGlynn, 2008; Moore, 2007; Johnson & Romanello, 2005). Technology tools, like Tablet PC's or hand-held PDAs, could also be used to create interactive lectures by allowing trainees to fill in a class outline or respond to key questions as the lecture progresses. These interactive tools allow learners to share ideas and collectively brainstorm by submitting responses the entire class can see instantaneously.

As "digital natives," 21st century learners have spent their entire lives surrounded by the toys and tools of the digital age: computers, videogames, digital music players, DVD players, digital cameras, and cell phones. Technology is an assumed part of the environment. Millennials expect instructors to use technology to communicate, and many consider a balanced use of technology in the learning environment to be essential (Herz, 2005). A variety of technologies beyond the common power-point lecture are available to incorporate into the learning environment. Email, online chat, wikis and blogs can also help build collaboration and communications skills (Hartman, Moskal & Dziuban, 2005). Online social networks such as Second Life, e-science labs and e-humanities can provide access to expensive or scarce high-level tools. When guided by training objectives, small-scale shifts in technology use can offer trainees meaningful learning experiences and increased interactivity.

Since 21st century learners have strong visual-spatial skills, incorporating visual tools into teaching and learning helps students process and remember important information. "Visual tools are nonlinguistic symbol systems that graphically link mental and emotional associations to create and communicate rich patterns of thinking" (Hyerle, 2009, p xix). These visual-spatial-verbal displays of information help visual-spatial thinkers translate information into personal knowledge. They are also metacognitive tools that help learners reflect upon their thinking. There are four kinds of visual tools: brainstorming webs, graphic organizers, conceptual maps, and Thinking Maps. They can be used as communication tools for collaboration and networking or to help an individual organize their thoughts. Research in the neurosciences suggests that the human brain organizes information in networks and maps, and the brain is dominantly visual receiving about 70 percent of the information from our environment through our eyes (Wolfe, 2004). New computer and digital technologies are reinforcing this dominant processing ability. Unlike linear- auditory lectures, visual tools actively engage students in the process of learning and can include opportunities for parallel processing - thinking about and doing more than one thing at a time. The combination of visual and verbal processing through mapping allows the human brain to engage in dual coding, which when focused on specific content can optimize human learning and memory (Marzano, Pickering, & Pollock, 2001).

Another recommended method for meeting 21st century learners' needs is Problem Based Learning (PBL), which provides learners with choices and decision-making opportunities that require them to take responsibility for their own learning, engage in meaningful work, and reflect

upon their learning. PBL encourages learners to be self-directed by constructing new knowledge from problem solving experiences (Brown, 2005). In PBL, students are presented with a problem they attempt to solve using knowledge and reasoning skills they already possess. Interactively, they identify the knowledge and skills they are lacking, and design a plan for meeting their learning needs. After seeking the new information or practicing needed skills, they apply their newly acquired knowledge and skills to the problem, and describe what they have learned (Ben-Jacob, Levin, & Ben-Jacob, 2000). An important part of this cycle is identifying knowledge deficiencies relative to the problem; these knowledge deficiencies become the learning issues that students need to research in order to solve the problem (Hmelo-Silver, 2004). Students can then utilize different avenues to research information; texts and written materials, online e-laboratories, publications databases, films, documentaries, or internet connections across the globe with experts in the field. PBL helps trainees become active constructors of knowledge, knowledge that is learned in meaningful contexts that are similar to those in which they will work (Artino, 2008).

Incorporating metacognition, asking students to reflect upon their learning, is an important component of effective teaching for 21st century learners. Metacognition engages learners by getting them to analyze their own learning strategies and make decisions about what kinds of learning experiences and information they still need to fully understand the material. Neuroscience research on human learning has found that synaptic connections are reinforced and strengthened by self-monitoring metacognitive activities, improving memory and efficient retrieval of information (Bradsford, Brown & Cocking, 1999). Metacognitive modeling by instructors teaches students how to become effective life-long learners and guides them in self-regulatory practices to foster a sense of competence and honing their own critical-thinking skills (McGlynn, 2005), as well as metacognition and nurture self-regulation (Muller, 1998).

In summary, this literature review identified several key attributes of 21st century learners including the following:

a. desire for meaningful work
b. are self-directed
c. prefer social interaction & collaboration
d. have a sense of competence
e. have strong visual-spatial skills
f. have strong parallel processing skills
g. are technologically literate

This review also identified best practices for 21st century learners. Teaching practices that draw on learners' strengths and preferences include:

a. cooperative learning
b. technology tools
c. visual tools
d. problem-based learning
e. content-related parallel processing
f. opportunities for choices and decision-making and selecting learning strategies
g. establishing high expectations
h. frequent praise and feedback

i. metacognition
j. meaningful work

The most effective learning context is one in which the teaching methods optimize learners' strengths and preferences.

2. Data Gathering Tools

To investigate the relationship between technical training teaching methods and trainees' learning preferences, classroom observation and preference inventories were employed.

A. Classroom Observation was the method selected to assess the degree of alignment between recommended 21st century training practices and current technical training practices. Classroom Observations have been used in traditional teacher training for decades. One such example is the PRAXIS III, based upon nineteen criteria divided into four domains developed by the Educational Testing Service. A three-point rubric rating system is used to score observed evidence for each criteria from which sub-scores are computed for the four domains. In states using the PRAXIS III, first year teachers must achieve a passing rating in each of the domains to be licensed to teach in public schools. This approach to classroom observation served as a model for developing an observation rubric for this pilot study.

The 21st Century Technical Training Observation Rubric (TTOR) was developed using the learner attributes/preferences and best instructional practices identified in the review of literature (See Attachment A). The rubric has nine criteria with three or more examples of possible evidence one might observe. For example, possible evidence for the criteria *self-direction* are: a) students exhibiting confidence in their own ability to learn with statements like "I know how to do this," getting right to work on assignments, helping peers, elaborating beyond basic understandings; b) students selecting appropriate learning strategies like drawing a web or diagram following an explanation to clarify meaning for self; c) students making choices about their learning experiences by selecting between options in assignments or selecting the sequence for completing a set of activities.

The first eight criteria describe 21st century instruction and the ninth criteria permitted the documentation of traditional instruction:

1. Training is <u>meaningful</u> to trainees
2. Training supports <u>self-direction</u>
3. Training incorporates <u>metacognition</u>
4. Training supports <u>collaboration</u>
5. Training supports a trainee's sense of <u>competence</u>
6. Training supports <u>parallel processing</u>
7. Training uses <u>technology</u> to support learning
8. Training includes trainees learning in a <u>variety</u> of ways
9. Training uses <u>traditional</u> methodology

Prior to implementation, the rubric was piloted by the observation team using several teaching videos to allow the raters to apply the criteria, discuss observed evidence for clarity, and to develop inter-rater reliability.

B. The Grasha-Reichmann Learning Styles Inventory (Attachment B) was selected as the instrument to measure the learning preferences of a sample group of technical trainees. The instrument is a 60 item Likert-type rating scale with response options from 1- strongly disagree to 5 strongly agree. The inventory is scored by averaging the ratings for ten items associated with six different learning styles:

> **Independent** students prefer independent study, self-paced instruction, and working alone on course projects.
> **Dependent** learners look to the teacher and to peers as a source of structure and guidance and prefer an authority figure to tell them what to do.
> **Competitive** students learn in order to perform better than their peers do and to receive recognition for their accomplishments.
> **Collaborative** learners acquire information by sharing and cooperating with the Instructor and peers. They prefer lectures with small group discussions and group projects.
> **Avoidant** learners are not enthused about attending class or acquiring class content. They are typically uninterested and are sometimes overwhelmed by class activities.
> **Participant** learners are interested in class activities and discussion, and are eager to do as much class work as possible. They are keenly aware of, and have a desire to meet teacher expectations.

Based on the literature about 21st century learners, trainees were expected to score higher in Collaborative and Participant styles, and to score lower in Competitive, Independent, and Avoidant styles. A moderate score in the Dependent style was also anticipated based on the need 21st century learners have for authority figures to provide high expectations, frequent praise, and feedback.

While the six learning styles identified by the LSI correlate to some degree with the learning preferences being studied, they did not directly align with the 21st century preferences identified in our literature review and no items addressed technology use. Therefore, ten additional items related to technology use for learning were added to the end of the LSI, creating a 70 item inventory. Then the items from the inventory were mapped to the identified 21st century attributes to enable the computation of sub-scores representative of 21st century learning preferences. The mapping process identified six LSI items related to each 21st century preference, with the exception of parallel processing for which no related items could be identified. Some items were negatively related to a 21st century preference so those ratings were interpolated (1=5, 2=4, etc) prior to calculating the sub-scores. Table 1 displays the LSI item mapping. Interpolated items are designated with a negative sign (-).

Table 1. LSI Items for Measuring 21st Century Preferences

21st C. Preference	**LSI Items**					
Meaningful	-8	12	-14	18	30	36
Self-direction	19	-28	43	48	49	5
Metacognition	7	24	25	31	53	55
Collaboration	3	9	15	21	39	45
Competence	4	6	10	29	46	59
Technology	62	64	65	66	67	70
Traditional	1	16	22	34	40	52

Once the LSI items for the 21st century preference were identified, a comparison was made with the items associate with the six LSI learning styles to note which items were shared by each LSI learning styles and 21st century preferences. This process suggested the anticipated LSI styles scores: high scores on the 21st century preferences would also be reflected in higher preferences for the Participant and Collaborative learning styles, moderate preferences for the Dependent, Independent, and lower preferences for the Competitive and Avoidant styles. The numbers of items associated with each LSI learning style used to measure each 21st century preference are noted in Table 2. Negatively related items are noted with a negative sign (-).

Table 2. Number of Shared Items Measuring 21st Century Preferences and LSI Learning Styles

21st C. Preference	LSI Learning Style Items
Meaningful	4 Participant, 2(-) Avoidant
Self-direction	2 Independent,2 Participant,1 Collaborative,1(-) Dependent
Metacognition	4 Independent,1 Participant,1 Competitive
Collaboration	6 Collaborative
Competence	3 Dependent,2 Competitive,1 Participant
Technology	6 Technology

C. The Grasha-Reichmann Teaching Styles Inventory (Attachment C) was selected as the instrument to measure the teaching preferences of a sample group of technical training instructors. The instrument is a 50 item, Likert-type rating scale with response options from 1-strongly disagree to 5 strongly agree. The inventory is scored by averaging the ratings for eight items associated with each teaching styles:

Expert teachers possess knowledge and expertise that students need; strives to maintain status as an expert among students by displaying detailed knowledge and by challenging students to enhance their competence; concerned with transmitting information and insuring that students are well prepared.

Formal Authority teachers possess status among students because of knowledge and role as instructor; concerned with providing positive and negative feedback, establishing learning goals, expectations, and rules of conduct for students; concerned with the correct, acceptable, and standard ways to do things and with providing students with the structure they need to learn.

Personal Model teachers believe in "teaching by personal example" and establish a prototype for how to think and behave; oversee, guide, and direct by showing how to do things, and encouraging students to observe and then to emulate the instructor's approach.

Facilitator teachers emphasize the personal nature of teacher-student interactions; guide and direct students by asking questions, exploring options, suggesting alternatives, and encouraging them to develop criteria to make informed choices; develop in students the capacity for independent action, initiative, and responsibility while providing as much support and encouragement as possible.

Delegator teachers are concerned with developing students' capacity to function in an autonomous fashion and work independently on projects or as part of autonomous teams with the teacher available upon request as a resource person.

As with the LSI, no items on the TSI addressed technology use, so parallel versions of the ten items related to technology use developed for the LSI were added to the end of the TSI, creating a 60 item inventory. The score for technology was computed by averaging the ratings for the ten technology items.

Grasha's research (1996, 2002) identified four common clusters of teaching styles and associated student learning styles that resulted in the most effective teaching-learning dynamic. Each of the Teaching Styles Clusters are made up of two or three primary teaching styles and one or more secondary styles. Below is a brief description of the four clusters and the learning styles for which they are most effective.

1- Expert/Formal Authority with Personal Model/Facilitator/Delegator. Most effective with Dependent/Participant/Competitive learners who have little or no need for a relationship with the instructor or other students. The instructor has low sensitivity to students' learning style preferences. Instruction includes: exams, grades, guest speakers/interviews, lectures, teacher-centered questioning and discussions, term papers, tutorials, and technology– based presentations (i.Powerpoint).

2- Personal Model/Expert/Formal Authority with Facilitator/Delegator. Most effective with Participant/Dependent/Collaborative learners who desire relationships with instructors and fellow students. Instructor has moderate to high sensitivity to students' learning style preferences, engenders respect and is liked by students. Instruction includes: role modeling, illustration, demonstration, examples, discussions of alternative approaches, sharing thought processes for obtaining answers, sharing personal experiences, coaching and guiding with feedback, students actively emulate instructor.

3- Facilitator/Personal Model/Expert w/Formal Authority/Delegator. Most effective with Collaborative/Participant/Independent learners who are willing to take initiative and accept responsibility for learning tasks. Instructor exercises some control over learning processes to facilitate learning; has professional, friendly and warm relationships with students, and has moderate to high sensitivity to students' learning preferences. Instruction includes: case studies, cognitive mapping/visual tools discussions, critical thinking discussions, fishbowl discussions, guided readings, key statements with discussion, lab projects, problem-based learning, role playing, simulations, roundtable discussions, and peer teaching.

4- Delegator/Facilitator/Expert w/ Formal Authority/Personal Model. Most effective with Independent/Collaborative/Participant learners who take responsibility and initiative. Instructor gives up control over students, develops rapport, empowers students, helps students develop good relationships with peers, has moderate to high sensitivity to students' learning preferences, approaches learning as working together with students in a more relational based dynamic. Instruction includes: contracts, symposiums, debates, teams/trios, independent study/research, jigsaws, self-paced modules of instruction, panel discussions, position papers, self-discovery activities, small work groups, journals, and internships/practicum.

Based on the literature about 21st century learners' attributes and preferences, and the best practices for 21st century learners, the Cluster 2 combination of teaching styles best aligns with the identified needs of 21st century learners. Given the expectation that current technical training

instruction was not aligned with the needs of 21st century learners, Cluster 1 teaching styles scores were anticipated for the sample of technical training instructors.

3. Data Collection and Analysis

Data were collected in October, 2008 during three days of technical training at Sheppard AFB. Instructors and students in six technical training courses were observed and asked to complete the preference inventories. Inventory responses were compiled using electronic scanning equipment and data were analyzed using add-in statistical analysis software for Microsoft Excel 2007. Observation ratings were complied and analyzed in Excel 2007.

A. Observations. Instruction (n=17) in six technical training courses was observed to document the teaching methods used in a range of career fields. One Instructors' Training class was also observed. The observation protocol involved teams of two or four raters observing each class for 20-30 minutes, note-taking during the observation period followed by assigning ratings based on the evidence noted. Raters completed their ratings individually for each criteria using a 0-3 rating scale (0= not observed, 1= seldom observed, 2= observed about half of the time, 3= observed most or all of the time). Following each morning or afternoon observation period, all four observers gathered to discuss their evidence and their individual ratings for each class. Most observations resulted in common ratings across the observers but when differences in individual ratings occurred, discussions of evidence resulted in the raters reaching consensus. Even on the few occasions when team teaching was observed, one rating for instruction was recorded for the class. Ratings for the nine criteria were totaled for each observed class resulting in a total observation score. The optimal total score was 26, based on a score of 3 for the eight 21st century criteria and a score of 2 for traditional methodology. Table 3 displays a summary of the observation data by course. Table 4 displays the mean rubric ratings by criteria.

Table 3. Instruction Observation Data Summary

Course (# observed)	Mean	% of optimal score 26
Maintenance (2)	15	57.7%
Munitions (2)	14	53.8%
Communications (4)	15.5	59.6%
HVAC (2)	13.5	51.9%
Medical (6)	13.3	51.1%
Pharmacy (1)	20	76.9%
Instructor Training (1)	11	42.3%
All Courses	14.6	56.2%

Table 4. Mean Observation Rubric Ratings by 21st Century Criteria

21st C. Criteria	Mean Rating (0-3)
Meaningful	2.00
Self-direction	.94
Metacognition	1.80
Collaboration	1.53
Competence	1.76
Parallel processing	1.47
Technology	.11
Variety	2.18
Traditional	2.59

Overall, observed instruction was dominantly traditional using lecture with slides. These methods are used in Grasha's Teaching Styles Cluster 1. The course with the highest level of observed alignment with 21st century instruction was Pharmacy (76.9 percent), in which students were actively participating by working at lab stations mixing a prescription cream. The course with the lowest observed alignment was in the instructor training course, where students sat in rows listening to a lecture with slides.

The mean criteria ratings document that the observed technical training instruction addressed the identified 21st century learning preferences less than half of the time. Two criteria received mean ratings of 2.00 and 2.18, suggesting that half of the time instruction was *meaningful* to students and included some *variety* (auditory, visual, kinesthetic). Overall, observation data indicated that the majority of the time technical training instruction was not aligned with 21st century best practices.

B. The Grasha-Reichmann Learning Styles Inventory (LSI) was completed by a sample of technical trainees (n=172) to identify their learning style preferences. Mean rating scores were computed for each of the six LSI learning styles plus technology and for seven 21st century learning preferences. The mean learning styles scores are presented from highest to lowest in Tables 5 and the mean ratings for the 21st century preferences are presented from highest to lowest in Table 6.

Table 5. Mean Ratings (scale 1-5) for Technical Trainees' LSI Learning Styles

Learning Style	Mean
Participant	4.13
Dependent	3.91
Collaborative	3.9
Technology	3.75
Independent	3.31
Competition	2.71
Avoidant	2.26

Table 6. Mean Ratings (scale 1-5) for Technical Trainees' 21st Century Preferences

21st C. preference	Mean
Meaningful	4.03
Collaboration	3.95
Metacognition	3.83
Competence	3.82
Technology	3.76
Self-direction	3.65
Traditional	3.27

The mean ratings were highly reflective of the range of responses with medians and modes similar to the mean ratings. The notable exception was technology, where the mean was 3.74 and the median 3.8, but the mode (the most frequent response) was 5.

These data suggest that the sampled technical trainees have similar learning preferences as those identified in the literature review for 21st century learners. These findings support the hypothesis that technical trainees are 21st century learners with 21st century learning preferences.

Given the preferred learning style composite for technical trainees was Participant/ Dependent/Collaborative, Grasha's (1996, 2002) research suggests the most effective instruction is Teaching Styles Cluster 2- Personal Model/Expert/Formal Authority with facilitator/delegator. Instruction aligned with trainees' preferences would include: role modeling, illustration, demonstration, examples, discussions of alternative approaches, sharing thought processes for obtaining answers, sharing personal experiences, coaching and guiding with feedback, trainees actively emulating the instructor, cooperative learning, visual tools, problem-based learning, choices, and metacognition.

C. The Grasha-Reichmann Teaching Styles Inventory was completed by a sample of technical training instructors (n=22) to identify their teaching style preferences and determine the level of alignment between the teaching preferences of technical training instructors and identified "best practices" to meet the needs of 21st century learners. Mean scores were computed for each of the five teaching styles. The styles were then placed in rank order from highest to lowest and used to identify the Teaching Style Cluster preferred by the sample of instructors. The mean teaching styles scores are presented from highest to lowest in Table 7.

Table 7. Instructors' Mean Ratings on TSI Teaching Styles

Teaching Style	**Mean Rating** (scale 1-5)
Personal Model	3.48
Expert	3.44
Formal Authority	3.37
Facilitator	3.04
Delegator	2.60
Technology	2.57

Mean ratings indicated that instructors preferred Grasha's Teaching Styles Cluster 2- Personal Model/Expert/Formal Authority with facilitator/delegator. This Teaching Styles Cluster aligns with technical trainees' Participant/ Dependent/Collaborative learning styles composite. The teaching methods associated with these preferences include: role modeling, illustration, demonstration, examples, discussions of alternative approaches, sharing thought processes for obtaining answers, sharing personal experiences, coaching and guiding with feedback, and trainees actively emulating the instructor. However, observed instruction was dominantly lecture, which is representative of Teaching Styles Cluster 1. This misalignment between instructors' preferences and classroom observation data suggests that while instructors would prefer to teach using 21st century best practices they are not currently using these methods in technical training. In addition, Technology received a 2.57 mean rating by instructors and a 3.75 mean rating by trainees, indicating that while trainees prefer greater technology use in training that do instructors, both groups agree that training should include the use of email, electronic course materials, PDAs, computers, and other technology tools.

6. Findings and Recommendations

The review of literature identified several common preferences of 21st century learners. They desire meaningful work, are self-directed, prefer working collaboratively, have a sense of competence, have strong visual-spatial and parallel processing skills, and are technologically intuitive. The Grasha-Reichmann Learning Styles Inventory (LSI) was administered to 172 trainees to identify their preferred learning styles and to determine whether they have the 21st century learning preferences identified in the literature. Trainees' responses on the LSI indicate that AF technical trainees are 21st century learners with 21st century strengths and learning preferences as reflected in a learning styles composite of Participant/Dependent/Collaborative.

The Grasha Teaching Styles Inventory (TSI) was administered to 22 technical training instructors in six courses to identify their preferred Teaching Styles Cluster. Instructors' responses on the TSI indicated that they preferred Teaching Style Cluster 2- Personal Model/Expert/Formal Authority with secondary preferences for the facilitator/delegator styles. Grasha's research suggests that Teaching Styles Cluster 2 best supports students with the Participant/Dependent/Collaborative learning styles composite. This finding suggests that technical training instructors' preferred teaching cluster was aligned with the learning preferences of 21st century technical trainees, with the exception of technology use for learning. Trainees preferred more technology use in training than did their instructors. The diagram below illustrates these relationships.

TSI (instructors) Preferences		**LSI (students) preferences**			
Personal Model	3.48	Participant	4.1	Avoidant	2.3
Expert	3.44	Dependent	3.9	Independent	3.3
Formal Authority	3.37	Collaborative	3.9	Competitive	2.7
Facilitator	3.04				
Delegator	2.60				
Technology	2.57	Technology	3.7		

Higher mean ratings in the Participant and Collaborative styles were anticipated and validated by the data. Moderate ratings were anticipated for the Dependent and Independent styles with low

ratings for the Competitive and Avoidant styles. Trainee data resulted in these anticipated ratings with the exception of a slightly higher than anticipated Dependent style score. Even so, the anticipated learning style composite was validated.

An interesting finding from these data was that the LSI and TSI data indicated alignment between instructors' and trainees' preferences, but the classroom observation ratings using the 21st Century Technical Training Observation Rubric indicated instruction was predominantly traditional. Observation ratings and notes documented the use of lectures, teacher-centered questioning, and slide presentations. These methods are representative of Grasha's Teaching Styles Cluster 1- Expert/Formal Authority with the secondary styles of personal model/facilitator/ delegator. So while instructors preferred Teaching Styles Cluster aligned with the preferences of technical trainees, instructors were not observed teaching with Cluster 2 instruction. In exploring this contradiction, it is helpful to understand the finer differences between these two clusters.

Teaching Styles Clusters 1 and 2 share two primary and two secondary styles; Expert/Formal Authority and facilitator/delegator. Both clusters also address the needs of participant and dependent learners, but differ in relationships with students. Cluster 1 emphasizes expertise and authority, and employs traditional instructional strategies which are most effective with competitive learners who do not desire relationships with instructors. Cluster 2 emphasizes the personal model which is most effective with collaborative learners who do desire relationships with instructors. The literature on 21st century learners and the findings from this pilot study suggest that technical trainees are Collaborative not Competitive in their learning preferences, and value relationships. They are Dependent and Independent learners in that they desire choices, feeling competent, need feedback and guidance but not control by instructors. These are important distinctions that directly impact the effectiveness of instruction.

The alignment between instructors' and trainees' preferences is good news, in that it suggests that instructors possess the desire and inclination to teach in ways that support 21st century learners' needs for participation, support and collaboration. However, observed instruction did not utilize recommended 21st century practices such as: cooperative learning, role modeling, illustrations, problem-solving, multiple examples, discussions of alternative approaches, sharing of thought processes for obtaining answers, sharing of personal experiences, coaching and guiding with feedback, or visual tools. Since instructors preferred but were not observed enacting 21st century teaching methods in the classroom, there is need for further exploration of this contradiction. Perhaps aspects of the training environment or the structure of the curriculum are constraining instructors from teaching in their preferred styles cluster. This is certainly an area worthy of further research.

The findings of this pilot study suggest that technical training instruction could be better aligned to meet both instructors' preferred teaching styles cluster and trainees' learning preferences. Adjustments in teaching methods could be made to accommodate these preferences. The incorporation of methods like cooperative learning, problem-based learning, metacognition, and visual tools would be fairly low-cost modifications that could significantly improve engagement and learning. The following is an example of using a cooperative learning approach to quickly change the learning experience observed during a classroom observation completed during this study:

The observed teaching method involved the instructor reading sections of a technical order (TO) and calling on various students to read aloud statements from the TO. During class, several students were trying to keep from nodding off and others were told by the instructor to stand to avoid falling asleep. A 21st century interactive, collaborative approach would use cooperative learning to teaching this information. To set up the cooperative learning experience, the instructor would make 4 enlarged copies of the TO, cut the statements apart and place the statements for each copy in a large envelope. The students would be placed in trios and each group would receive an envelope with the TO statements. Given a limited but sufficient time block to complete their work student trios would reconstruct the TO by reading, discussing, and putting the statements in the proper order. When finished, they would tape the reconstructed document on a poster page and display it on the wall. Then the instructor would reveal the TO on a slide and ask the teams to check how accurately they reconstructed the TO and discuss how/why they made their ordering decisions.

By using this approach, every student must participate in not just reading the TO statements, but in discussing and making sense of the statements with their teammates in order to put the statements in the proper order. This process engages students in collaboration and shared meaning-making through a shared purpose. They must think through the TO task process and make decisions about which steps should be completed in which sequence. These are the kinds of 21st learning methods that could quickly be included in training at minimal cost. A “toolbox” of these kinds of 21st century instructional strategies could be incorporated into Instructor Training.

More technology access and use in the classroom is another avenue to engage trainees and improve training outcomes. Trainees expressed the desire for more technology use in the classroom and for digital access to course materials. Even though instructors’ responses on technology items were lower than those of trainees, they did indicate they would like to incorporate more technology into the training process. Adjustments in teaching to include more technology tools would accommodate both instructors’ and trainees’ preferences. A variety of technologies beyond the common power-point lecture are available to incorporate into the learning environment. Electronically available course materials, email communications, online wikis and blogs could be incorporated to provide collaboration and interactivity. When guided by training objectives, small-scale shifts in technology use could offer trainees meaningful learning experiences to increase engagement and improve learning outcomes. Further research is needed to determine the impact of incorporating the use of simple technology tools in technical training.

Several questions worthy of research arose from this study, especially those that focus on the relationships and interconnections between Learners, Instructors, and Curriculum.

- What role does curriculum design play in shaping/constraining instruction?
- What would class lessons look like if 21st century criteria were used to guide curriculum design?
- What models of instruction are included in instructor training?
- Do the methods of instruction in instructor training support 21st century/Cluster 2 teaching methods like: role modeling, illustration, demonstration, examples, discussions of alternative approaches, sharing thought processes for obtaining answers, sharing personal experiences, coaching and guiding with feedback, students actively emulating the instructor?

- What would instructor training look like if the 21st Century Technical Training Observation Rubric (TTOR) criteria were used for assessing instruction?

As a pilot study with a small sample of instructors and courses, further research to validate these findings would also be helpful and appropriate next steps. Technical trainees are 21st century learners who deserve to be fully engaged in their technical training, and 21st century instructional practices are more likely to help them succeed. Improving technical training instruction through the use of 21st century best practices and incorporating more technology use in the learning process are viable avenues worthy of further investigation.

REFERENCES

Abram, S. (2007). Millennials: Deal with them! Part II. *School Library Media Activities Monthly*, 24(2), 55-58.

Artino, A.R. (2008). *A brief analysis of research on problem-based learning*. Educational Resources Information Center (ERIC Document Reproduction Service No. ED501593).

Ben-Jacob, M., Levin, D. & Ben-Jacob, T. (2000). The learning environment of the 21st century. *International Journal of Educational Technology*, 6(3), 8-12.

Blascovich, J.J. & Hartel, C.R. (2008). *Human behavior in military contexts*. National Research Council. www.nap.edu/catalog/12023.html.

Bradsford, J.D., Brown, A.L., & Cocking, R.R. (Eds.) (1999). *How people learn: Brain, mind, experience, and school.* National Research Council. Washington, D.C.: National Academy Press.

Brown, J. (2005). Learning spaces. In D. Oblinger & J. Oblinger (Eds.). *Educating the net generation*. Chapter 12. Electronic book. www.educause.edu/ educatingthenetgen/.

Center for Information Research on Civic Learning & Engagement (2007). *Millennials talk politics: A study of college student civic engagement*. www.civicyouth.org/PopUps/CSTP.pdf.

Dordai, P. & Rozzo, J. (2006). Echo boom impact. *American School & University*, 79(3), 300-303.

Eisner, E. (2005). Managing generation Y. *SAM Advanced Management Journal*, 70(4), 4-15.

Grasha, A.F. (1996, 2002). *Teaching with style: A practical guide to enhancing learning by understanding teaching and learning styles.* Pittsburgh, PA: Alliance Publishers.

Hartman, J., Moskal, P., & Dziuban, C. (2005). Preparing the academy of today for the learner of tomorrow. In D. Oblinger & J. Oblinger (Eds.). *Educating the net generation*. Chapter 6. Electronic book. www.educause.edu/ educatingthenetgen/.

Herz, J.C. (2005). The space between: Creating a context for learning. *Educause Review*, 40(3), 30-38.

Hmelo-Silver, C. (2004). Problem based learning: What and how do students learn? *Educational Psychology Review*, 16(3), 235-266.

Howe, N. & Strauss, W. (1991). *Generations: the history of America's future 1584-2069*. New York: William Morrow and Company, Inc.

Hyerle, D. (2009). *Visual tools for transforming information into knowledge* (2nd Ed). Thousand Oaks, CA: Corwin Press.

Johnson, D.W., Johnson R.T., & Stanne, M.B. (2000). *Cooperative learning methods: A meta-analysis.* Minneapolis, MN: University of Minnesota. www.co-operation.org/pages/cl-methods.html.

Johnson, D.W. & Johnson R.T. (1997). *Learning to lead teams: Developing leadership skills*. Edina, MN: Interaction Book Company.

Johnson, S.A. & Romanello, M.L. (2005). Generational diversity: Teaching and learning new approaches. *Nurse Educator*, 30(5), 212-216.

Koster, K. & Smith, A. (July 2007). *From workplace to marketplace: How millennial work values translate into brand opportunity*. Minneapolis, MN: Iconoculture, Inc. www.iconoculture.com.

McGlynn, A. (2005). Teaching millennials: our newest cultural cohort. *Education Digest,* 71(4), 12-16.

McGlynn (2008). Millennials in college: How do we motivate them? *Education Digest*, 73(6), 19-22.

Martin, C. & Tulgan, B. (2006). Managing the generation mix (2nd Ed). Amherst, MA: HRD Press. www.rainmakerthinking.com/pdf%20files/mix2007.pdf.

Marzano, R.J., Pickering, D.J., & Pollock, J.E. (2001).*Classroom instruction that works: Research-based strategies for increasing student achievement.* Alexandria, VA: Association for Supervision and Curriculum Development.

Montana, P. (2008). Motivating generation X and Y on the job, and preparing Z. *NACE Journal,* 68(3), 28-32.

Moore, A. (2007). They've never taken a swim and thought about jaws: Understanding the millennial generation. *College and University,* 82(4), 42-48.

Muller, J. (1998). The well-tempered learner: Self-regulation, pedagogical models and teacher education policy. *Comparative Education*, 34(2), 177-193.

North Central Regional Educational Laboratory/Metiri Group (2003). enGauge 21st century skills: Literacy in the digital age. Los Angles, CA: Metiri Group.www.metiri.com/features.html

Northwestern Mutual (2004). Millennium generation studies, the fifth study: Eager but anxious. Milwaukee, WI: Northwestern Mutual. www.nmfn.com/tn/learnctr--studiesreports--fifth_study.

Oblinger, D. & Oblinger, J. (Eds.) (2005). *Educating the net generation*. Electronic book, www.educause.edu/ educatingthenetgen/.

Oblinger, D.G. (2003). Boomers, Gen-Xers, Millennials: Understanding the "new students". *Educause Review*, 38(4), 37-47.

Prensky, M. (2001). Digital natives, digital immigrants. From *On the Horizon* (MCB University Press, Vol. 9 No.5, October).

Raines, C. (2003). Managing millennials. In C. Raines, *Connecting generations: The sourcebook for a new workplace*. Menlo Park, CA: Crisp Publications.

Roberts, G. (2005). Technology and learning expectations of the net generation. In D. Oblinger & J. Oblinger (Eds.). *Educating the net generation*. Chapter 3. Electronic book. www.educause.edu/ educatingthenetgen/.

Rodgers, M., Runyon, D., Starrett, D., & VonHolzen, R. (2006). Teaching the 21st century learner. In *22nd Annual Conference on Distance Teaching and Learning*. Minneapolis, MN: The Board of Regents of the University of Wisconsin. www.uwex.edu/disted/conference/

Skiba, D., & Barton, A. (2006). Adapting your teaching strategies to accommodate the net generation of learners. *Journal of Issues in Nursing*, 11(2), 15.

Vander Schee, B.A. (2008). Millennials and politics: A new mix. *Student Affairs Leader*, 36(4), 4-4.

Wagner, J. (2005). Support services for the net generation. In D. Oblinger & J. Oblinger (Eds.). *Educating the net generation.* Chapter 10. Electronic book. www.educause.edu/ educatingthenetgen/.

ATTACHMENT A
21st Century Technical Training Observation Rubric (TTOR)

TECHNICAL TRAINING OBSERVATION RUBRIC

Course________ Block ________Unit ________ Instructor ____________ Date __________

Rate the frequency of the training attribute using the following Rating Scale:
Indicators and specific examples of observable behaviors are provided for each attribute
0= not observed 1= seldom observed 2= observed about half the time 3= observed most or all of the time

___Training is meaningful to trainees as evidenced by trainees:
_____ Completing assignments that aligns with lesson goals
_____ Making connections between experiences and lesson content ("This is like when I had to …)
_____ Generating questions about lesson content
_____ Actively participating in the lesson (making comments, eye contact, listening)
_____ Applying what they learn to real-life situations
_____ Transferring learning across lessons/units (using prior knowledge, identifying similarities between lessons)
_____ Solving real work problems

___Training supports self direction as evidenced by trainees:
_____ Exhibiting confidence in their own ability to learn ("I know how to do this", getting right to work on assignments, helping peers, elaborating beyond basic understandings)
_____ Selecting appropriate learning strategies (drawing a web or diagram following an explanation to clarify for self)
_____ Making choices about their learning experiences (options in assignments or selecting the sequence for completing a set of activities)
___Training incorporates metacognition as evidence by trainees:
_____ Monitoring their own understanding of concepts (asking questions to get clarification)
_____ Monitoring their own skill level (checking to see how well they are doing, asking for guidance)
_____ Monitoring the quality of their work (checking work, comparing work to exemplars)
_____ Identifying their own learning needs ("I don't understand", asking for help, requesting alternative explanations)
___Training supports collaboration as evidenced by:
_____ Trainees showing respect for one another (tone, language, addressing people by name)
_____ Trainees and Instructor showing respect for one another (tone, language, addressing by name)

_____ Trainees accepting personal differences (not making fun of dialects or language or abilities)
_____ Furniture arrangements that encourage interaction (tables and chairs in groups)
_____ Assignments/events that require cooperation/teamwork (tasks with 2 or more trainees discussing and working together)
_____ Peer teaching (a trainee explaining content to another trainee)

___Training supports the trainee's sense of <u>competence</u> as evidenced by:

_____ Assignments that fits the trainee's readiness level
_____ High, attainable expectations (Instructor states belief in trainees' capacity to learn)
_____ Frequent praise and recognition from instructor (Good job, well done)
_____ Opportunities for the trainee to engage in decision-making
_____ Trainees discuss the basis of standards, guidelines, and rules
_____ Instructors accommodate learning differences (teach to different learning styles)

___Training supports <u>parallel processing</u> as evidenced by:

_____ Flexible instructional materials (all course materials available to use as needed, easy to read/understand, presented in a variety of learning modalities)
_____ Muti-sensory learning experiences (visual, oral, kinesthetic)
_____ Displays relevant to current instruction
_____ Active manipulation/exploration of learning materials by trainees (trainees get to handle materials and make/learn from mistakes not just observe a demonstration)
_____ Trainees using resources and strategies in real-life contexts (simulations, labs, flight line)
_____ Evaluation and feedback occur while learning in happening (Instructor observes and comments on performance related to specific competencies)
_____ Trainees have opportunities for task-related multi-tasking (simultaneous use of course materials, technology, and coaching while completing a task)

___Training <u>uses technology</u> to support learning as evidenced by trainees:

_____ Using technology (computers, hard and soft trainers) during the training event
_____ Providing and receiving feedback electronically (email, text messages)
_____ Using technology to access learning materials (course materials available online/CD/PDA)
_____ Interacting with experts in the field using technology (chat, email, distance conference)
_____ Using technology to solve problems (computer-based information, examples, cases)
_____ Playing interactive web-based games/simulations to learn specific skills

___Training includes trainees learning in a <u>variety</u> of ways:

_____ Orally (answers to questions, discussions, debates)

_____ Written (practice exercises, completing worksheets, essays, tests)
_____ Visual (drawing diagrams, using cognitive organizers)
_____ Performances (demonstrations, presentations, skits, videos)
_____ Using different learning or processing styles

___Training uses <u>traditional</u> methodology as evidenced by

_____ Delivery of content through lecture
_____ Delivery of content using visual aids (PowerPoint, video clips, posters)
_____ Delivery of content using demonstrations on hard or soft trainers
_____ Interactions between instructor and trainee rather than between trainees
_____ Interactions that are instructor initiated (instructor asks questions)
_____ Trainees completing assignments individually
_____ Reading assignments and worksheets

ATTACHMENT B
Grasha-Reichmann Learning Styles Inventory with Technology Items

LSI & Technology Survey

Course _________ Years of Service ___ Age ___ Date _________ Survey____

Respond to the items listed below by using the following scale.

Use a rating of 1 if you *strongly disagree* with the statement.
Use a rating of 2 if you *moderately disagree* with the statement.
Use a rating of 3 if you are *undecided*.
Use a rating of 4 if you *moderately agree* with the statement.
Use a rating of 5 if you *strongly agree* with the statement.

1. I prefer to work by myself on assignments in my courses
2. I often daydream during class.
3. Working with other students on class activities is something I enjoy doing
4. I like it whenever teachers clearly state what is required and expected
5. To do well, it is necessary to compete with other students for the teacher's attention.
6. I do whatever is asked of me to learn the content in my classes
7. My ideas about the content are often as good as those in the textbook
8. Classroom activities are usually boring.
9. I enjoy discussing my ideas about the course content with other students.
10. I rely on my teachers to tell me what is important for me to learn.
11. It is necessary to compete with other students to get a good grade.
12. Class sessions typically are worth attending.
13. I study what is important to me and not always what the instructor says is important.
14. I very seldom am excited about material covered in a course.
15. I enjoy hearing what other students think about issues raised in class.
16. I only do what I am absolutely required to do in my courses.
17. In class, I must compete with other students to get my ideas across.
18. I get more out of going to class than staying at home.
19. I learn a lot of the content in my classes on my own.
20. I don't want to attend most of my classes.
21. Students should be encouraged to share more of their ideas with each other.
22. I complete assignments exactly the way my teachers tell me to do them.
23. Students have to be aggressive to do well in courses.
24. It is my responsibility to get as much as I can out of a course
25. I feel very confident in my ability to learn on my own
26. Paying attention during class sessions is very difficult for me to do.
27. I like to study for tests with other students.
28. I do not like making choices about what to study or how to do assignments.
29. I like to solve problems or answer questions before anyone else can.
30. Classroom activities are interesting
31. I like to develop my own ideas about course content
32. I have given up trying to learn anything by going to class
33. Class sessions make me feel like a part of a team where people help each other learn.
34. Students should be more closely supervised by teachers on course projects.

35. To get ahead in class, it is necessary to step on the toes of other students.
36. I try to participate as much as I can in all aspects of a course
37. I have my own ideas about how classes should be run.
38. I study just hard enough to get by.
39. An important part of taking courses is learning to get along with other people
40. My notes contain almost everything the teacher said in class.
41. Being one of the best students in my classes is very important to me.
42. I do all course assignments well whether or not I think they are interesting.
43. If I like a topic, I try to find out more about it on my own.
44. I typically cram for exams.
45. Learning the material is a cooperative effort between students and teachers.
46. I prefer class sessions that are highly organized.
47. To stand out in my classes, I complete the assignments better than other students.
48. I typically complete course assignments before their deadlines.
49. I like classes where I can work at my own pace.
50. I would prefer that teachers ignore me in class.
51. I am willing to help out other students when they do not understand something.
52. Students should be told exactly what material is to be covered on the exams.
53. I like to know how well other students are doing on exams and course assignments.
54. I complete required assignments as well as those that are optional.
55. When I don't understand something, I try to figure it out for myself.
56. During class sessions, I tend to socialize with people sitting next to me.
57. I enjoy participating in small group activities during class.
58. I like it when teachers are well organized for a session.
59. I want my teachers to give me more recognition for the good work I do.
60. In my classes, I often sit toward the front of the room.
61. I would use a computer to access training course materials.
62. I would use a computer to training submit assignments
63. I would use a mobile or handheld computer device (Personal Digital Assistant or Cell Phone) to access training course materials
64. I would use a mobile or handheld computer device to submit training assignments
65. I would interact with technical experts in the field using online chat or email
66. I would interact with my instructors using online chat or email
67. I would like to learn new technical skills on the computer
68. I would like to practice technical skills on the computer
69. I would like to play interactive web-based games to learn
70. I would like to receive feedback from instructors by online chat or email

ATTACHMENT C
Grasha-Reichmann Teaching Style Inventory with Technology Items

TSI* & Technology Survey

Course _________ Years of Service ___ Age ___ Date _________ Survey____

Respond to the items listed below by using the following scale.

Use a rating of 1 if you *strongly disagree* with the statement.
Use a rating of 2 if you *moderately disagree* with the statement.
Use a rating of 3 if you are *undecided*.
Use a rating of 4 if you *moderately agree* with the statement.
Use a rating of 5 if you *strongly agree* with the statement.

1. Facts, concepts, and principles are the most important things that students should acquire.
2. I set high standards for students in this class.
3. What I say and do models appropriate ways for students to think about issues in the content.
4. My teaching goals and methods address a variety of student learning styles.
5. Students typically work on course projects alone with little supervision from me.
6. Sharing my knowledge and expertise with students is very important to me.
7. I give students negative feedback when their performance is unsatisfactory.
8. Students are encouraged to emulate the example I provide.
9. I spend time consulting with students on how to improve their work on individual and/or group projects.
10. Activities in this class encourage students to develop their own ideas about content issues.
11. What I have to say about a topic is important for students to acquire a broader perspective on the issues in that area.
12. Students would describe my standards and expectations as somewhat strict and rigid.
13. I typically show students how and what to do in order to master course content.
14. Small group discussions are employed to help students develop their ability to think critically.
15. Students design one of more self-directed learning experiences.
16. I want students to leave this course well prepared for further work in this area.
17. It is my responsibility to define what students must learn and how they should learn it.
18. Examples from my personal experiences often are used to illustrate points about the material.
19. I guide students' work on course projects by asking questions, exploring options, and suggesting alternative ways to do things.
20. Developing the ability of students to think and work independently is an important goal.
21. Lecturing is a significant part of how I teach each of the class sessions.
22. I provide very clear guidelines for how I want tasks completed in this course.
23. I often show students how they can use various principles and concepts.
24. Course activities encourage students to take initiative and responsibility for their learning.
25. Students take responsibility for teaching part of the class sessions.
26. My expertise is typically used to resolve disagreements about content issues.

27. This course has very specific goals and objectives that I want to accomplish.
28. Students receive frequent verbal and/or written comments on their performance.
29. I solicit student advice about how and what to teach in this course.
30. Students set their own pace for completing independent and/or group projects.
31. Students might describe me as a "storehouse of knowledge" who dispenses the facts, principles, and concepts they need.
32. My expectations for what I want students to do in this class are clearly defined in the syllabus.
33. Eventually, many students begin to think like me about course content.
34. Students can make choices among activities in order to complete course requirements.
35. My approach to teaching is similar to a manager of a work group who delegates tasks and responsibilities to subordinates.
36. There is more material in this course than I have time available to cover it.
37. My standards and expectations help students develop the discipline they need to learn.
38. Students might describe me as a "coach" who works closely with someone to correct problems in how they think and behave.
39. I give students a lot of personal support and encouragement to do well in this course.
40. I assume the role of a resource person who is available to students whenever they need help.
41. I have used/would use a computer to provide online course materials to students
42. I have accepted/would accept students' assignments electronically
43. I have used/would use a mobile or handheld computer device (Personal Digital Assistant or Cell Phone) to provide course materials to students.
44. I have used/would use a mobile or handheld computer device to receive students' assignments.
45. I have interacted/would interact with experts in the field using online chat or email.
46. I have interacted/would interact with my students using online chat or email.
47. I have/would have students learn new technical skills on the computer.
48. I have/would have students practice technical skills on the computer.
49. I have/would have students play interactive web-based games to learn.
50. I have provided/would provide feedback to students using online chat or email
51. I am willing to help out other students when they do not understand something.
52. Students should be told exactly what material is to be covered on the exams.
53. I like to know how well other students are doing on exams and course assignments.
54. I complete required assignments as well as those that are optional.
55. When I don't understand something, I try to figure it out for myself.
56. During class sessions, I tend to socialize with people sitting next to me.
57. I enjoy participating in small group activities during class.
58. I like it when teachers are well organized for a session.
59. I want my teachers to give me more recognition for the good work I do.
60. In my classes, I often sit toward the front of the room.
61. I would use a computer to access training course materials.
62. I would use a computer to training submit assignments
63. I would use a mobile or handheld computer device (Personal Digital Assistant or Cell Phone) to access training course materials
64. I would use a mobile or handheld computer device to submit training assignments

65. I would interact with technical experts in the field using online chat or email
66. I would interact with my instructors using online chat or email
67. I would like to learn new technical skills on the computer
68. I would like to practice technical skills on the computer
69. I would like to play interactive web-based games to learn
70. I would like to receive feedback from instructors by online chat or email

ACRONYMS

AETC	Air Education and Training Command
AFRL	Air Force Research Laboratory
AFSO-21	Air Force Smart Operations 21^{st} Century
ASVAB	Armed Services Vocational and Aptitude Battery Test
CAMS	Core Automated Maintenance System (CAMS)
IETMs	Interactive Electronic Technical Manual (IETM)
ISD	Instructional Systems Development
JAMRS	Joint Advertising, Market Research and Studies
LSI	Learning Styles Inventory
TACS	Technology for Agile Combat Support
TRW	Training Wing
TSI	Teaching Styles Inventory
TTMS	Technical Training Management System
TTOR	Technical Training Observation Rubric